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ECOLOGICAL PROJECTS
FOR USE IN
SECONDARY BIOLOGY

by

© PAUL PAETKAU

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF ZOOLOGY

EDMONTON, ALBERTA

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Ecological Projects for Use in Secondary Biology" submitted by Paul Paetkau, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

A study of the ecological component in secondary school biology as taught in the province of Alberta was conducted during the years 1969-73. The study determined the provision for the teaching of ecology and the provision for the use of ecological projects. A review of textbooks and curriculum guides indicated that ecology could be taught in grades seven, ten, eleven and twelve, and that grades ten and eleven provided the greatest opportunity for the use of ecological projects.

Secondary biology teachers in the Camrose region of Alberta were interviewed to determine if assistance was desired in the area of ecological projects. The results of the questionnaire completed by these 22 teachers indicated a definite desire for assistance.

A major portion of this study was an attempt to respond to this request for assistance. A book of ecological projects was written in an attempt to provide this assistance. The book consisted of both a teacher's and a student's section, the former containing factual material and teaching hints; the latter, collecting and culturing methods, problem statements, suggested experimental designs and a series of leading questions. All projects in these books were based on 31 local, common animal groups such as protozoa, hydras, frogs, etc.

The effectiveness of this book as a teaching aid and as a resource book for projects was evaluated by three groups of teachers and students, i.e., the pilot study group, the summer school group and the 1973 group. The pilot study involved the testing of a representative booklet of projects by 277 students in 11 schools situated in the City of Edmonton

and in the rural areas around Edmonton. The results of the pilot study indicated that the senior high school biology teachers felt that the projects were a very good source of ideas and that the books were useful as a teaching aid. The results from use in the grade seven classrooms were not so clear and judgement regarding the usefulness of the projects at this level had to be reserved.

Nine teachers enrolled in a summer school senior biological methods course in the Faculty of Education, University of Alberta, personally conducted and evaluated some of the writer's projects. In summary, these teachers rated the projects as being suitable for the average Alberta secondary school.

Fifty-four teachers in the Peace River area, Yellowhead School District #12 and the City of Calgary participated in the 1973 evaluation. Two hundred and eighty-four senior high school biology students from 35 different schools sent in post-use questionnaires. Questions on pre- and post-use teachers' questionnaires and on post-use students' questionnaires were statistically analyzed and discussed. In summary, it can be stated that the majority of the teachers rated the books as being useful for secondary school biology and that the majority of the students rated the books as being interesting.

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INTRODUCTION

The study of biology may serve a number of educational purposes. Ramage (1967) believes there are two ways in which biology can be of value in human education. He states:

> "More narrowly, it can make a utilitarian contribution to the vocational training of the relatively small numbers of people who intend to follow some kind of career involving biology... More widely, biology can play a helpful part in the general personal and social education of everyone..."

Lecoq (1967) in discussing the teaching of biology in France elaborated as follows:

> "In France, the teaching of natural sciences, particularly biology at the secondary level, by continual modification of methods, reaches progressively toward the end for which it strives; namely, not only to help the acquisition of basic knowledge which is indispensable to certain careers, but also to help children become men who have the qualities of mind which will enable them to find their place in the modern world. By thrusting them into the vast world of nature, we will get them to know life, and we will stimulate them to behave towards it with reason and caution."

The above objectives of teaching biology are nobly stated. The last sentence appears to clarify the problem and offer a relatively straightforward solution. In the light of prevailing environmental conditions in North America one questions whether the above was written in a serious vein. Problems arise when one attempts to translate these objectives into action. How can one achieve the **objective** of getting children, and later, adults to behave toward nature with "reason and caution"? Southwood (1967) is of the opinion that if one is to achieve this objective, then "...biology must not stop at the outer skin of the animal or the epidermis of the plant, as virtually happened in schools a decade ago, but must extend beyond the individual to the population and community; that is, modern biology must include an ecological component". It does not seem too difficult to agree with Southwood. Such agreement on the part of the writer has led to questions regarding the ecological component in modern biology as taught in the Province of Alberta. The search for answers to these questions led to the clarification of the following objectives in this study:

1. To determine the provision made for the teaching of ecology in secondary education in the Public School Systems of the Province of Alberta in the school year of 1969-70.
2. To determine the provision for the use of ecological projects in secondary education in the Public School System of the Province of Alberta in the years 1969-70.
3. To determine whether assistance may be required in the form of ecological projects in the teaching of ecology and if so, how it may be rendered.
4. To attempt to provide such assistance if required.
5. To attempt to evaluate the effectiveness of this assistance.

LIMITATIONS OF THE STUDY

Certain limitations have already been listed in the objectives. The study was limited to the Province of Alberta and to the study of ecology and ecological projects in the field of biology. The review of textbooks and curriculum guides further restricted the latter part of the study to grades seven, ten, eleven and twelve. The teachers who were interviewed and who participated in the classroom evaluation of this study were, therefore, grade seven teachers or high school biology teachers.

Teacher interviews indicated a desire for assistance in the area of resource oriented projects. It was decided to attempt to provide this assistance in the form of a resource and idea book concerning ecological projects. A number of limitations had to be imposed on the design of this book. The teacher interviews, committee meetings, literature reviews, teacher and student feedback, and personal experiences were all instrumental in determining the following limitations imposed on the design.

LIMITATIONS OF THE BOOK AND PROJECT DESIGN

1. Book design limitations. The information presented in the book had to be presented in such a manner so as to be easily accessible to the average busy classroom teacher.
2. The projects were to serve as a source of ideas i.e. as teaching aids. Therefore, they had to be designed to be as flexible as possible so that any teacher could use and adapt them to his or her individual teaching style and to the limitations imposed by his teaching situation.
3. The projects were to be designed primarily for students at the grade ten and eleven level but be so designed that grade seven and grade twelve students could use them as well.
4. The projects should be compatible with the objectives of secondary school biology and with the objectives of project teaching in secondary school biology (Appendix F).
5. The projects should be flexible enough so that they could be conducted by a total class, by small groups or by individual students.

6. The projects should be designed considering Alberta weather, and the present teaching of ecology in the school year. The majority should be, therefore, designed for the fall and spring seasons.
7. The projects should require only the use of simple equipment such as could be found in most homes or secondary schools in Alberta.
8. The literature resources required to complete the project should not greatly exceed those found in the average Alberta home or secondary school.
9. The projects should use common, local animals. These animals should be easily obtainable and if necessary easily cultured.
10. The projects should be designed to avoid the possibility of any legal or humane objections to the manner in which the animals were being used in the projects.

RELATED LITERATURE

After investigating material available on this topic, it can be stated with reasonable certainty that a similar study had not been done previously. This fact, coupled with the broad nature of the study, made it very difficult to determine the limits of the literature review. However, a number of studies, sourcebooks, texts, and periodicals were especially helpful. These will be dealt with in this review.

Literature Related to Environmental Studies

The present study was concerned with the field of environmental studies or environmental education. Leopold (1949) in discussing the concept of ecological conscience provided some fundemental observations and questions. He stated;

> "Conservation is a state of harmony between men and land. Despite nearly a century of propaganda, conservation still proceeds at a snail's pace; progress still consists largely of letterhead pieties and convention oratory. On the back forty we still slip two steps backward for each forward stride.
>
> The usual answer to this dilemma is 'more conservation education'! No one will debate this, but is it certain that only the volume of education needs stepping up? Is something lacking in the content as well?
>
> ...But the education actually in progress makes no mention of obligations to land over and above those dictated by self-interest. The net result is that we have more education but less soil, fewer healthy woods, and as many floods as in 1937."

Watts (1969) in his review of environmental studies in Great Britain, assisted by providing a definition for this field. He stated:

> "The essential concept of Environmental Studies, which can be embodied in both elementary and advanced work is interrelationships; the interrelationship of the features of the environment, and the relationship between the student and his environment. The notion of interrelationship not only characterizes Environmental Studies, but usefully distinguishes it from those studies which manifestly isolate certain features from the environment in order to more clearly understand them. A necessary concomitant of this interrelationship is direct experience, for it is this which brings the features within the student's environment."

A booklet explaining the meaning of the United States Environmental Education Act signed by President Nixon on October 30, 1970, provided further clarification.

> "Environmental education is a lifelong process. It is a way of looking at life, fostering awareness of other life and of interrelationships, learning to recognize the effects (good and bad) we have on physical surroundings, and the responsibilities we must accept for the mere fact of our presence and of our activities in our environment... Environmental education provides alternate ways of thinking-synthesis-which colors and affects the humanities, languages, social sciences, history, economics, and religion as dramatically as it does the natural sciences. It will give an ecological perspective for every aspect of learning."

A final definition is provided by Ames (1971). He states that in environmental education "A high priority would be placed on the processes of inquiry and problem solving but the focus would be outward into the community and on actual problems affecting the lives of the students". It appeared that any study aimed at providing some assistance in the field of environmental education should promote the involvement of the student in direct experience with his environment so that he could note the interrelationships found there.

Literature Related to Project Teaching

A number of authors helped to define the meaning of a project and the meaning of project teaching. Miller and Blaydes (1962) state:

> "Often teachers speak of using the project method when the 'project' consists of little more than the making of special reports on library readings or the assignment of minor individual problems. These are worthy procedures, but isolated problems of this sort are not projects. A project includes a series of related problems and may cover a small portion of subject matter or an entire course. The problems are usually so begun that those attempted first suggest or even demand those which follow."

Cole (1934) also emphasied the project as "a problem or a series of problems" but he stipulated that a project must also include activities. The purpose of these activities was to "reach some end or objective". Richardson (1957) stated that "Generally the project includes some physical outcome - a product, display, or perhaps a written report".

The project method is not new, as witnessed by the date of Cole's publication (1934), yet there appears to be a reluctance on the part of teachers to use it. One indication of the reluctance may be the fact that biology projects were not included as a formal part of the Alberta high school biology curriculum until 1969. Most authors agree with Washton (1967) that the project method can be used to teach "important scientific principles and attitudes" and can be used to "develop excellent investigative procedures for inquiry". They would also probably agree that it can be used by teachers to provide for the needs of individuals or small groups of students. For example, Miller and Blaydes (1962) in their textbook state:

> "The method of teaching by projects is widely accepted as a desirable procedure in education. It is especially useful in the sciences where many of the materials are of the so-called laboratory and field types. The project method also offers the student the opportunity of learning by activity, seeing, doing, and handling."

However, these same authors provide an explanation for the discrepancy between the desirable state the actual state.

> "This method requires the highest type of teaching in every respect. It necessitates more detailed planning, more foresight, more skill on the part of the teacher. In short, it is more work and therefore frequently shunned."

Richardson (1957) further elaborates on some of the problems associated with project teaching.

> "One of the first problems confronting the science teacher in planning project work is that of having a range of appropriate projects. Dependence upon a list of titles of projects has not been too satisfactory because such a list does not provide sufficient detail to be as valuable as many teachers would like."

It appeared therefore that any study aimed at providing some assistance in the field of environmental education should provide the teacher with a range of detailed projects so that the teacher could help the student become involved in some direct experiences with his environment and the interrelationships of its various components.

Literature Related to Some Further Limitations Imposed on the Projects

Theses prepared by Jacknicke (1968) and Dyke (1970) in the Department of Secondary Education, University of Alberta, provided further valuable direction regarding some of the limitations of the projects. Jacknicke conducted a study of the use and possible use of local freshwater organisms for teaching purposes. Part of his study consisted of questioning eleven grade eight and grade eleven teachers in the County of Lacombe regarding their use of local organisms. He concluded that: "During the 1966-67 school year, biology teachers in the County of Lacombe made very limited use of the local resources available to them. Only a small percentage collected and cultured live organisms". He also stated that: "The most common reasons given for not using local resources were that the collecting of specimens is too time-consuming and that many teachers lack the knowledge of what organisms exist in the local environment, where they can be found, and how they can be collected and cultured". The majority of teachers did, however, express the opinion that locally collected, living specimens are valuable aids in the teaching of biology. The most common reason given by these teachers for using such resources was that it helps to stimulate interest and motivate students. One of Jacknicke's interview questions also asked the teachers where they obtained their local organisms. The results indicated that students brought in the majority of organisms with only a small number of teachers becoming involved in any type of collecting activity.

Dyke's (1970) results corroborated the last point. She interviewed thirty randomly-selected grade eight science teachers in Edmonton to determine the extent of use, and teacher attitude toward the uses of live wild mammals in the classroom. Only six of the teachers used live mammals in the classroom. In all of these cases pupils were responsible for bringing the animals to school. "The bats and field mice were caught by hand in the wild, while the other animals were domestic animals kept as pets. In all instances, the pupils were responsible for the complete care of the animals " (Dyke, 1970).

It therefore appeared that, if projects were to promote the involvement of the students in direct experiences with their environment, detailed information regarding the collecting and culturing of all organisms involved should be provided directly to the student as well as to the teacher.

Literature Related to Factual Information For the Projects.

Much of the information regarding the animals used in the projects, i.e. their distribution, life histories, best collecting and culturing methods, etc. has been gathered by the writer through his years of association and work with the fauna of Alberta. It is difficult to give proper credit to the sources of all the ideas for the projects and the translation of these ideas into problems which can be handled by secondary school students. A number of the ideas and all of the feeling for the type of suitable problem has developed as a result of the writer's teaching experience. The information for the projects has been gathered through the use of different books over the years, by contact with biology instructors, by contact with biologically trained co-workers, and by personal experiences. It is, therefore, difficult to document the source of all information and ideas. However, considering these limitations the following were of assistance in providing information for this section.

The books by Paetz and Nelson (1970), Salt and Wilk (1958) and Soper (1964) were very helpful in providing the local distribution of fish, birds and mammals respectively. The Resource Reader, a publication of the Saskatchewan Department of Natural Resources, was very helpful in providing information about the distribution of reptiles and amphibians in Alberta. This information was supplemented by the checklist of Alberta reptiles and amphibians published by the University of Alberta, Department of Zoology (1964).

Some general collecting and culturing methods were obtained from sources such as Brandwein et al. (1958), Morholt et al. (1966) and Klinckmdn (1970). Turtox (1944), UNESCO (1962), Ellis et al. (1964) and Showalter and Slesniek (1966) were especially helpful in obtaining culturing information suitable for the average school. Dyke (1970) was also useful in providing culturing information for small mammals suitable for the average Alberta school.

Some general life history information was gained from the Alberta guides already mentioned and Stebbins (1954) was very helpful with respect to the amphibians and reptiles. Pennak (1953) and Borror and DeLong (1954) provided useful information regarding the aquatic invertebrates and the terrestrial insects respectively. A series of pamphlets published by both the Federal and Provincial Departments of Agriculture proved very informative for so-called pest animals such as mosquitoes, Dixon et al. (1971), grasshoppers, Craig (1971) and houseflies, Dixon and Petersen (1970). A number of Department of Zoology, University of Alberta theses such as those by Murray (1964) on small mammals, and Paetkau (1964) on the hydras helped to verify half-forgotten information.

Odum (1971) proved to be an excellent source regarding concepts and principles of ecology while Benton and Werner (1965) provided field ecology techniques. Lehman (1968) provided an outline to follow in the research and development of trial forms of biology and laboratory field investigations for secondary biology.

METHODS

TEXTBOOK REVIEWS

To determine the provisions made for the teaching of ecology the relevant textbooks were reviewed. A list of the recommended textbooks was obtained from the Department of Education Curriculum Guide for each course. However, the teacher in most cases has the option of using one, several, or none of the recommended textbooks. It is therefore difficult to determine exactly what resource material is being utilized in the teaching of any part of any course short of interviewing every teacher in the province. An indication of the use of resource material was gained by determining the numbers of each textbook sold to teachers. Since the School Book Branch, Department of Education is the only retail outlet for new textbooks in the province, this provides quite a reliable index. It is recognized that teachers may be using used textbooks or a variety of other resource materials to supplement, or at times to replace the use of the authorised textbooks. Mr. Fedorak, Assistant Manager of the Book Branch, provided information about the sale of textbooks in the field of science and biology.

CURRICULUM GUIDE REVIEWS

The Department of Education provides each teacher in the province with a Curriculum Guide for the course he is teaching. This Guide contains information regarding the content of the course, methods of developing the concepts, suggestions for the use of teaching aids, lists of additional reference books as well as the previously mentioned list of recommended textbooks. Therefore a review of this Guide provides another index of the provisions made for the teaching of ecology and ecological projects in the Province of Alberta.

CAMROSE TEACHER INTERVIEWS

An interview method was selected to determine whether assistance in the form of ecological projects might be useful in the teaching of ecology and if so, how it might best be rendered. All schools teaching grade seven science and/or grade ten and eleven biology in the City of Camrose School District #1315 and in the rural area of Camrose School District #22 were initially selected for this study. The reasons for the selection of these grades will be discussed later. Two schools in the County of Camrose were rejected: one because of low enrollment in the biology course (two students) and the other because of an atypical teaching situation. In the latter case the course was being taught part time by a retired teacher. All grade seven science and grade ten and eleven biology teachers were interviewed in the other schools. The interviews were conducted during the week of May 17-22, 1970 and during the interview the teacher was asked to complete a written questionnaire (Appendix A). A dictaphone was used to record any other comments by the teacher. An additional personal information questionnaire (Appendix B) was sent to these teachers in January, 1972. The teachers in this group will hereinafter be referred to as Camrose teachers.

BOOK AND PROJECT DESIGN

The animal kingdom was reviewed and those animals not eliminated by any of the constraints listed on pages three and four were selected as possible study animals. Life histories of possible project animals were next studied. During this review ideas concerning possible projects which might illustrate concepts and principles of ecology and which could be conducted within the limitations imposed by the design were noted. Projects were then outlined, and a representative sample was field tested.

PROJECT EVALUATION

Pilot Study Evaluation

The Camrose teachers were again visited during the month of April, 1972. In addition teachers in schools in other districts within a 100 mile radius of Edmonton and some teachers in the City of Edmonton Public and Separate school systems were visited in April-May, 1972. The number of teachers contacted was limited by time, distance and budget. Teachers eligible for the study (see below) were left a copy of Pilot Study Evaluation Questionnaire #1 (Appendix C) and a sample booklet of projects containing all student and teacher material related to using protozoans, hydras, earthworms, snails, mosquito larvae, houseflies, pheasants and grouse. Eligibility was based on three conditions:

1. The teachers must have used ecology projects in their teaching within the last two years.
2. The teachers had to agree to have students complete at least some parts of projects using two different animal groups before the middle of June, 1972.
3. The teachers had to agree to complete and return Pilot Study Evaluation Questionnaire #1 within one week and to complete and return Pilot Study Evaluation Questionnaire #2 (Appendix D) promptly

when sent to them in June, 1972.

The booklets and Questionnaire #1 were then further explained to participating teachers. The teachers in this group will hereinafter be referred to as pilot study teachers.

Summer School Evaluation

Each student participating in a three week summer school course, taught by the writer, was asked to conduct concurrently three different projects. These students were enrolled in a senior biology methods course in the Department of Secondary Education, University of Alberta. This group will hereinafter be referred to as summer school teachers because the students were all teachers. Assistance in the form of a written experimental design was provided for the first project, and a series of problems was provided verbally for the second project. No assistance was given in the design or in the selection of the third project. The first two projects were selected from a list of names of animal groups, i.e. earthworms, ants, etc. The writer's appropriate project outline was then provided for the first selection while the appropriate problem statements were given verbally to the teacher for the second project. The projects were evaluated in a number of ways.

Approximately 30 minutes was alloted for a formal presentation of the results obtained in each project. The participating teacher or pair of teachers completed Summer School Evaluation Questionnaire #3 (Appendix E) just prior to the presentation. After the presentation, all students and the instructor individually rated the project using the relevant portions of Evaluation Questionnaire #3. The class as a group then completed question four of the questionnaire.. Teachers were asked to conduct and evaluate the projects as if they were secondary school biology students.

Just prior to termination of the course all teachers were also requested to complete question four of Pilot Study Evaluation Questionnaire #2. The main question was changed to read: "In your opinion how effective were the projects in motivating you to:".

1973 Evaluation

The results of the pilot project indicated that a larger sample size of teachers was desirable. They also indicated that one might obtain a different response from the grade seven teachers as opposed to the senior high school biology teachers. Since the projects were aimed primarily at senior high school and since time and economics required a choice it was decided to concentrate on the senior high school biology teachers. Senior high school biology teachers in the Yellowhead School District #12, the Peace River Area (Zone #1, Department of Education) and the City of Calgary were selected for the study. These areas were selected to obtain a good urban-rural cross section of schools. The sample size and geographical area covered was restricted by the distances between teachers and the time and money available to travel these distances. The proper authorities i.e. Superintendents, Principals, Education Consultants, etc. were contacted and teachers were informed when the writer would be visiting them. The teachers in this group will be hereinafter referred to as the 1973 teachers.

Teachers in the Yellowhead School District #12 were visited on January 29 and 30, 1973. One teacher in this area was not contacted personally but was visited by Mr. K. W. Kluchky, Education Consultant, Department of Education, on behalf of the writer. Most teachers in Zone #1 i.e. Peace River Area, were visited by the writer and Mr. G. Gay, Education Consultant, Department of Education, on February 19 to 22, 1973. Distance and time restrictions did not allow us to visit four teachers in the Zone, however, these were contacted by telephone and all requested to become part of the study. Teachers in the City of Calgary were contacted on February 6, 1973. The procedure was different in this case in that the writer presented his material to the group of teachers attending a regular meeting of the Calgary Biology Teachers' Association.

The procedure for selecting teachers for the study was the same in all cases. Each teacher was asked to peruse a bound copy of the Teacher's Section and a bound copy of the Student's Section of the writer's book of projects. The Teacher's Section contained all of the information related to all of the animal groups while the Student's Section contained all of the information related to half of the animal groups. Every second animal group was included in each Student's book. For example, one teacher would receive a Student's book containing projects related to Protozoa, Planarians, Aquatic Earthworms, etc. while another would receive a Student's book containing projects related to Hydras, Earthworms, Leeches, etc. The reason for this arrangement was again one of economy. The objectives of the study and the contents of the books were then further explained to each teacher or in the case of the Calgary teachers, to the group. Teachers who wished to participate in the study and who were eligible for the study were then given their copies of the books. Eligibility was again based on three conditions as in the pilot study but the conditions were modified. The three conditions were:

1. The teachers must have used or were using projects in their teaching program.
2. The teachers had to agree to present the writer's materials to the students. This condition was modified from the pilot study. The rational for the change was that the selection of a project topic is voluntary in most schools and as such is not assigned by the teacher. The teacher only provides resource materials and ideas. The students for many reasons often reject any or all of the projects suggested by the teacher. The teacher therefore could not be asked to guarantee that the writer's materials would be used. The teacher could only be asked to present the books to the students and to recommend them as another source of projects and project ideas.
3. The teachers were asked to complete the 1973 Evaluation Questionnaire #1 (Appendix G) and were asked to have participating students complete the Student's Questionnaire (Appendix I) upon completion of their project. The questionnaires were personally collected from the teacher at this time. The teachers were informed that the writer would visit them in June, 1973 and would ask them to complete another questionnaire at that time. The 1973 Evaluation Questionnaire #2 (Appendix H) was sent to the teachers in May to allow them time to complete it prior to the visit in June.

Four of the six teachers in the Yellowhead School District #12 were again visited on June 1, 1973. One contacted the writer by telephone and the other was contacted by telephone by the writer. All Calgary teachers were visited on June 4, 5 and 6th, 1973. Eighteen Peace River area teachers were personally contacted during the week of June 11-15th 1973. One teacher was visited later by Mr. G. Gay, Department of

Education, on behalf of the writer and two contacted the writer by letter prior to the visit. Both of these teachers requested an extension of time to June 22, 1973. Both of these were later contacted by telephone.

Thus, based on a time scale, three groups were involved in the evaluative phase of this study; the Pilot Study teachers, the Summer School teachers and the 1973 group of teachers and students.

Explanation of Questionnaires

General

Objective five of this study stated the purpose of this evaluation. It was "To attempt to evaluate the effectiveness of this assistance". Effectiveness was to be measured in how well it served as resource material for the teacher. The evaluation therefore had to indicate whether in the opinion of the teacher concerned the ecological projects prepared could be used effectively as a teaching aid. Three main approaches could have been used to test this:

1. By having secondary biology teachers review and evaluate the projects.
2. By having practicing secondary biology teachers evaluate the projects based on students' use in an actual classroom situation.
3. By having students evaluate the projects following use.

The second choice was utilized as the main method of evaluation. The first choice was rejected on the basis that teachers may not be able to assess accurately the students' aptitude and interests in these projects. The third choice was rejected as a sole means of evaluation because teachers would not have been involved. The material was designed as a teaching aid, a resource, to be used in any manner chosen by the teacher. However, some the logistics problems associated with the third method of evaluation were solved by having the summer school teachers function as secondary biology students, and by having classroom students complete a simple questionnaire based on their use of the writer's projects.

Six questionnaires were used in the evaluation process. Evaluation Questionnaire #1 (Appendix C) and 1973 Evaluation Questionnaire #1 (Appendix G) were designed to be used by the teachers prior to the use of the writer's books. Pilot Study Evaluation Questionnaire #2 (Appendix D) and 1973 Evaluation Questionnaire #2 (Appendix H) were designed to be used after the use of the writer's books. Evaluation Questionnaire #3 (Appendix E) was designed to be used by the Summer School teachers involved in the study and the Student's Questionnaire (Appendix I) was designed to be used after a student had used some resource material from the writer's book.

Pilot Study Evaluation Questionnaire #1 (Appendix C)

The first question was designed to solicit personal information regarding the teachers involved in the study. Questions two and three were designed to ascertain the educational objectives of the teachers in regards to biology teaching and biology project teaching respectively. The objectives listed were six of the eight used by Nakayama (1970), to determine the goals of some biology, physics, chemistry and earth science teachers in Japan. Two of the objectives used in the Japanese study were judged to be redundant and were, therefore, eliminated from this study. The order in which the objectives were ranked was used to determine if the teachers thought science teaching was "giving knowledge about science" or promoting "science as inquiry".

Question four, consisting of a main question and 50 sub-questions, was an important section of this questionnaire. Twenty-three of the sub-questions were related to the cognitive domain and 27 were related to the affective domain. The cognitive domain was defined as those educational objectives emphasizing intellectual outcomes while the affective domain was defined as including those educational objectives emphasizing feeling and emotion.

Gronlund (1970) in his summarized version of Bloom (1956) lists six major categories in the cognitive domain. Listed and defined from the lowest to the highest level of learning they are:

"1. Knowledge. Knowledge is defined as the remembering of previously learned material.

2. Comprehension. Comprehension is defined as the ability to group the meaning of material.

3. Application. Application refers to the ability to use learned material in new and concrete situations.

4. Analysis. Analysis refers to the ability to break down material into its component parts so that its organizational structure may be understood.

5. Synthesis. Synthesis refers to the ability to put parts together to form a new whole.

6. Evaluation. Evaluation is concerned with the ability to judge the value of material for a given purpose."

Question four contained six sub-questions related to knowledge, five to comprehension, six to application, five to analysis, four to synthesis, and one to evaluation. The number of questions asked in each category was based largely on the availability of an appropriate instructional objective expression for each question.

Gronlund (1970) in his summarized version of Krathwohl (1964) lists five major categories in the affective domain. Listed and defined in the order of the lowest to the highest level of learning they are:

"1. Receiving. Receiving refers to the student's willingness to attend to particular phenomena or stimuli.

2. Responding. Responding refers to active participation on the part of the student.

3. Valuing. Valuing is concerned with the worth or value a student attaches to a particular object, phenomenon, or behaviour.

4. Organization. Organization is concerned with bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system.

5. Characterization by a Value or Value Complex. At this level of the affective domain the individual has a value system that has controlled his behaviour for a sufficiently long time for him to have developed a characteristic 'life style'."

Question four contained two sub-questions related to receiving, four to responding, eight to valuing, four to organization and five to the value complex.

The 50 questions were randomly mixed and presented to the teacher in the order indicated in Appendix C. The teachers were asked to rate, on a five point scale (poor to excellent), the effectivenes of the ecology-oriented biology projects completed by their students. This portion of the questionnaire was, therefore, designed to obtain baseline data for later comparison with the writer's projects.

Pilot Study Evaluation Questionnaire #2 (Appendix D)

Evaluation Questionnaire #2 was designed to obtain information regarding the use and the effectiveness of the writer's projects and the project book as a teaching aid. Question one allowed the teachers to check the actual use while question two directly asked the teachers to rate the whole of the project book, and various parts, as a teaching aid. Question three allowed for free expression of opinion. Question four consisted of the same 50 sub-questions as found on Pilot Study Evaluation Questionnaire #1. The only difference was that the questions had been randomly mixed again and that the teachers were now asked to rate the effectiveness of the writer's projects.

Summer School Evaluation Questionnaire #3 (Appendix E)

The third questionnaire was actually a project evaluation sheet designed to be used in classroom situations. It was designed by the writer but modified through discussion with the summer school teachers. The evaluation sheet contained four main sections; the first related to the project outline, the second to the manner in which the project was handled, the third to learning resulting from the project and the last to the suitability of the project to the average secondary school in Alberta.

1973 Evaluation Questionnaire #1 (Appendix G)

This questionnaire was a modified version of the Pilot Study

Evaluation Questionnaire #1 (Appendix C). The questionnaire was again designed to obtain baseline data for later comparison with the writer's projects. Question one was expanded to include the name, school, address and years of biology teaching experience of the teachers in the sample. Question two consisted of the same 50 sub-questions as found in question four of the Pilot Study Questionnaire #1. Questions two and three of the Pilot Study Questionnaire were not included in this questionnaire. Elimination of these questions was based on the minimal useful information derived from these questions and the expressed desire of the pilot study teachers for a shorter questionnaire.

1973 Evaluation Questionnaire #2 (Appendix H)

This questionnaire was a modified version of the Pilot Study Evaluation Questionnaire #2 (Appendix D). It was designed to obtain information regarding the use and effectiveness of the writer's materials as a teaching aid. A comparison of the two questionnaires indicates that question one of the original questionnaire was eliminated and question two became question one of the 1973 questionnaire and the rest of the questions followed in order. Question one could be eliminated because the students now provided this information on their questionnaire. Two additional questions were added on the 1973 Questionnaire. Question number four acknowledgdd that this material was only resource material and as such might not be selected for use by the students. The question was designed to determine reasons why the material was not selected for use.

Question number five developed as the writer visited the teachers in June, 1973. Most of the teachers apologized for the small number of participating students and provided reasons for the small number. These reasons will be discussed later. In most cases, these teachers also stated that they anticipated a greater use of the materials during the coming year. Question five was, therefore, quickly developed to record the number of teachers who expressed this opinion. The question was asked verbally by the writer during the visit. Teachers who had not expressed an opinion on this matter and had been visited before the question was formulated were lated phoned by the writer.

1973 Students' Questionnaire (Appendix I)

This questionnaire was designed to determine the students' reactions to the projects. Question one identified their project, question two allowed them to rate their interest in the project, the degree of difficulty and the adequacy of the instructions. Question three allowed them to judge the effectiveness of the projects in helping them to understand four main objectives of biology and ecological projects while question five again allowed them to express their interest in the project.

RESULTS

TEXTBOOK REVIEWS

A review of the textbooks sold (Table 1) indicated that biology was not being taught in grades eight and nine, therefore textbooks used in these grades were eliminated from this study. The grade twelve course was under revision in 1969-70, therefore textbooks for that grade were also excluded from this study. Textbooks purchased in the remaining grades in secondary education were reviewed to provide an indication of the provision for ecological content in each grade.

Review of "Exploring Life Science"

This textbook contains 15 units (Table 2) one of which deals directly with the science of ecology ("Plant and Animal Communities"). Two other units, "How to do Field Research" and "Man and his Environment" are closely related to this field. The other 12 units have application for ecology but do not deal directly with the subject. The provision for ecology teaching is however much greater than indicated by this simple breakdown because of the flexibility allowed to the teacher.

Flexibility is the keyword. Either several months, or very little time, could be spent on each unit. A review of the unit on "Plant and Animal Communities" may indicate the degree of flexibility.

The unit is divided into four main sections and a number of sub-sections (Table 3). The sub-sections vary in length and of course in content. The first sub-section on "Competition" and the last sub-section on "Effects of Animals on Succession" are presented to indicate this variation:

"Competition

Two organisms may compete with each other for space, for light, for food, and for water. Generally, the more alike two organisms may be, the more likely they are able to compete. The greatest competition takes place among members of the same species.

Plant 25 or more seeds of the same kind, such as radish seeds, in the same place in a pot of soil. For comparison, plant a few seeds two or more inches apart in another pot of soil. Give the two pots the same care.

Keep a daily record of the growth of the young plants, including the first appearance of new leaves, the height and size of the leaves, and their general appearance. If some seedlings die, note whether these are the largest or smallest individuals.

On the next page is shown a cross-section of the trunk of an aspen tree. This tree began to grow in a field with many other seedlings. In what year did the seed sprout? Fow how many years did the seedling grow rapidly? For how many years was growth very slow?

Early in 1937 many of the small trees in the field were thinned out, leaving wide spaces between the remaining trees. What was the effect on the growth of the tree? Explain these changes in growth.

The drawing below shows two perch taken from different lakes. Each is the same age. One lake was stocked with 1,500 fish per acre. The other was stocked with 180,000 fish per acre. Discuss the possible reasons for the difference in their size.

Effects of Animals on Succession

Changes made by climate, wind storms, fire and the activities of man cause most of the serious changes in natural communities. However, a few animals can also produce important changes.

What is the effect on a plant community when beavers build a dam? What new plants may arrive in the region? What new animals may arrive? Describe the possible succession after the beavers abandon the dam.

Cattle and other grazing animals produce important changes when they are numerous. Why might a forest change into a grassland if cattle are pastured there for a long period?"

Each unit of this textbook ends with a section which the Teachers' Manual titles "Independent Investigations". In most units these are divided into two categories, one demanding more sophisticated thinking than the other. The students' textbook generally calls these "Experimental Research" and "Other Investigations and Projects" respectively. Examples of these taken from the unit on "Plant and Animal Communities" are presented in Table 4. These end-of-chapter suggestions may be treated as purely voluntary or they may be assigned. "Some pupils may undertake special projects if allowed to substitute these for regular homework assignments" (Teachers' Manual).

These sections are then followed by a section called "Review Questions" and a final one called "Thought Questions" (Table 5). The review questions encourage pupils to recall what they have learned and to think about it while the thought questions are designed only as challenges for pupils who have developed the proper degree of sophistication. Therefore, this textbook does provide for the teaching of a great deal of ecology in grade seven science, but the amount actually taught depends upon the teacher.

Review of the Nuffield Biology Textbooks

The Nuffield series of biology texts have their origin in the Nuffield Science Teaching Project in Great Britain. Five textbooks for students and their accompanying teachers' manuals have been published. As can be seen in Table 6 special provision for ecology teaching has been provided in Text IV. Texts I and II are being used in Alberta. However, as stated in the preface to every textbook "The course has been built around a number of fundamental themes. Such issues as the relationship of structure to function, adaptation and the interaction of organism and environment recur in different contexts throughout the five year period. The course is designed to foster a critical approach to the subject with an emphasis on experimentation and enquiry rather than on the mere assimilation of facts". The preface to the Teachers' Manual also states "While the material contained in each chapter of the text is developed in a logical order, there is no set sequence to the course as a whole. Apart from the seasonal considerations, which are important for certain sections such as the work on some of the living organisms, it is intended that teachers should adapt the course freely to suit their own preferences and the facilities available". Therefore it would appear that even though teachers in Alberta are using Texts I and II and not Text IV, ecological concepts and principles could be stressed if desired. The emphasis on experimentation and enquiry and the use of live plants and animals in these experiments should provide opportunities for the inclusion of ecology teaching.

It should be noted that a Canadian version of Texts I and II is now available. Since this version was written by Alberta authors R. S. Melynchuk, K. G. Jacknicke, and H. P. Visscher, with editorial advice from Dr. C. G. Hampson, it should, because of its emphasis on local plants and animals, greatly assist any teacher who wishes to stress the ecological aspects of these texts.

Review of Biological Sciences Curriculum Study (BSCS) Materials

The BSCS texts resulted from a collaboration of teachers, educators and scientists. The appearance of the first Russian satellite provided an impetus for the formation of these committees. Since men of different interests and points of view contributed to the production of the BSCS materials a diversity of opinions appeared. "This diversity is reflected in the versions themselves: in their emphasis on different levels of biological organization, in differences in style, and in differing treatments of subjects within the field" (Klinckman, 1970). This resulted in three textbooks each with its own emphasis; the Green, the Yellow, and the Blue versions. The Blue version committee emphasized the molecular basis of biology, the Yellow stressed the cellular basis of biology while the Green version began with the raspberry bush and the rabbit: the ecological basis of biology. All had the common objectives indicated in Table 7 and all attempted to construct their texts around the unifying themes indicated in Table 8. Each however differed in the level of biological organization stressed (Table 9).

Review of High School Biology-BSCS Green Version

The Green Version was developed within the above general framework. Its aims were to "...encourage a scientific viewpoint in the student; ...provide him with a background in biology that is as advanced as he is able to assimilate; ...increase his effectiveness as a future citizen as well as to help him assess himself in his universe" Teachers' Guide. Because of these aims "the course was planned for the middle 60 percent (in interest and ability) of tenth-grade students". The levels of biological organization emphasized were the population, the community, and the world biome. Its focus of attention was ecology. This can be seen from both the table of contents (Table 10) and from the following opening statement in the Teachers' Guide (Bates, 1960).

> "The word 'ecology' was proposed by Ernst Haeckel in 1870 to cover what he called 'outer physiology'. It is the point of view in biology that takes the individual organism as the primary unit of study, and is concerned with how these individuals are organized into populations, species, and

> communities; with what organisms do and how they do it.
>
> This contrasts with 'inner physiology' the study of how the individual is constructed and how the parts work. Obviously the inside and outside of the organism are completely interdependent, and one cannot be understood without constant reference to the other. The division is arbitrary, but so are all of the ways in which biological subject matter might be split. We stress the outside rather than the inside on the assumption that this is more important for the citizen, who must participate in decisions about urban development, flood control, public health, conservation - always as a voter and sometimes as a member of the town council or state legislature.
>
> For disorders of inner physiology the citizen should consult his physician. But there is no specialist for outer physiology, for disorders of the human biological community. Here each citizen shares responsibility, and biological knowledge is greatly needed for some kinds of decisions."

A brief review of two of the chapters in this textbook may help clarify the provision for ecology teaching. The chapter on "Communities and Ecosystems" was chosen because of its similarity to the reviewed chapter on "Plant and Animal Communities" in the textbook Exploring Life Science. The chapter on cells was chosento note the difference in treatment as compared with the same subject in the Yellow Version.

A list of headings in the chapter on "Communities and Ecosystems" (Table 11) indicates that the course does not separate the lecture material from the laboratory material. Some content is provided, experiments are conducted and more content is presented providing answers to questions which may have arisen from the experiments. The two investigations, one analyzing a total biotic community as chosen by the teacher and the other obtaining temperatures in three different terrestrial habitats, do not have any set answers. The experimental, investigative approach is stressed. The chapter ends with a set of questions based directly on the chapter and a set of problems and suggested readings intended as extensions of the chapter (Table 12). In addition the Teacher's Guide contains a set of additional problems and one additional investigation (Table 13).

The other chapters are arranged in a similar manner. For example in the chapter on the cell students may conduct three investigations: diversity in cell structure, diffusion through a membrane, and mitosis and cell division in plant cells. The Teacher's Guide suggests that teachers start the chapter with the first experiment and concentrate their efforts in this chapter on the results of this investigation. The emphasis in the chapter is indicated by the title of this section; "Within the Individual Organism". The cell is viewed as a part of an organism interacting with its environment. Part of the second paragraph in the summary of the chapter in the student's textbook illustrates this emphasis.

> "Cells differ greatly in size, shape, and kinds of parts. In general, the cell consists of a nucleus and a cytoplast which can be distinguished by differences in reaction to stains. Within the cytoplast are organelles that carry on special cell functions. Separating the cell from its environment is a membrane; through it must pass, inward, all the materials the cell uses and, outward, all the materials the cell discards."

In all of these materials one can see that the emphasis is ecology. The Green Version was not intended to cover the whole field of biology nor was it intended to be used as a textbook for training future biologists. The intention is well indicated in the following statement. "Clearly, the writers believe that secondary-school science should be presented as an aspect of the humanities... The high school is not the place to begin the training of biological scientists" (Klinckman, 1970).

Review of Biological Science; An Inquiry Into Life - BSCS Yellow Version

"The educational challenges to the teachers and students using the BSCS Yellow Version, Biological Science: an inquiry into life. 2nded., New York: Harcourt, Brace & World, 1968, stem from the factors below.

1. This will be the only laboratory science course for many high school students.
2. For even more students, this will be their only contact with biology.
3. The rapid upgrading of high school biology has led many universties to shorten or eliminate their long-standing introductory course in general biology. Thus, for many students, this will be their only course attempting a general treatment of the field of biology.
4. Biology has long occupied an important place in the science curriculum in its own right but, today, it is becoming even more important in helping us to solve some of man's more urgent problems." Klinkman, 1970.

The main difference between the Green Version and the Yellow Version is the level of organization emphasized. The Yellow Version emphasizes the cellular, molecular, and organ and tissue levels while the Green Version emphasizes the population, community and world biome levels of organization. The reason is found in the second sentence of the third statement. This course attempts a general treatment of the field of biology while the Green Version emphasizes ecology as a basis for resource oriented decision making for the ordinary voter. In the Yellow Version ecology is stressed in one of the four parts of the text (Table 14) while the Green Version is based on ecology. The difference can be seen by comparing the summary statement on the cell in the Green Version with a similar statement in chapter 3 of the Yellow Version.

> "Unifying theories explain isolated facts. Science is at its best when it seeks a new theory to organize an accumulation of poorly understood facts. One of the greatest unifying theories of biology is that all, or nearly all, forms of life have a common basic structure. That this is true is not at all obvious: a fish and a tree really do not seem to resemble one another. Yet both are alike in being composed of cells. Cells were first discovered almost 200 years before their nature was

understood well enough to lead to the cell theory."

The Yellow version does not include the laboratory and field investigations in the same textbook, as the Green version does. However, the laboratories are quite similar, both being based on the discovery method. The three laboratory experiments in unit four; namely, a field study of a plant community, a field study of an animal community and a field study of ecological succession in two contrasting plant communities illustrate this.

Review of Modern Biology

> "The authors of MODERN BIOLOGY have always felt that the learning process should involve a mastery of certain fundamental biological concepts at the beginning of the program. From these initial understandings, the student should then progress from the cell to protists, to plants and animals, and to man. Culminating his biological knowledge, the interrelationships of living things and their environmental adaptations should bring about a clearer comprehension of the significance of life and its importance in human welfare. Accordingly, this revision of MODERN BIOLOGY contains the most recently available knowledge, but the authors have avoided selecting any one or two of these areas as deserving primary emphasis at the expense of other equally important areas" (Otto and Towle, 1965).

The above statement and the table of contents (Table 15) indicates the provisions for ecology teaching in this textbook. A laboratory manual accompanies the textbook. The three laboratory experiments in unit eight are quite similar in content to the BSCS ecology experiments, the first being an ecological analysis of two habitats, the second being a study of life in soil communities and the third being a study of succession in a jar of pond water. Therefore, some provision for the teaching of ecology is available if this textbook is used.

Related Materials

Additional BSCS material is listed in the Teachers' Guide for both the Green and Yellow versions. Because some teachers may be using these materials it was considered desirable to determine what provisions for ecology teaching they contain.

The BSCS Laboratory Blocks

These consist of a series of 13 individual books of laboratory investigations each designed for a six week 'block' of time. Their aim is to enable the student to experience on a somewhat reduced scale, the various processes used by scientists in biological research. They are designed for the average student and are to be used in the regular classroom. As indicated in Table 16, one of these laboratory blocks deals with ecology. Klinckman (1970) describes the laboratory block as follows:

> "A field area is mapped to establish permanent boundaries and a map of the area is drawn to scale by the class. Measurements are made of factors in the field area including temperature, moisture, light, and wind. Students, working in pairs, select an animal and a plant for observation during the six-week study. Sampling techniques are used to determine frequency, abundance, and cover of both animal and plant types. Correlations are determined between the structure of vegetation and environment. Measurements are made and students prepare pictorial diagrams of the vegetation cover. Experimentation is conducted in physiological ecology including transpiration, photosynthesis, respiration, and temperature of plants. In the final study, evidence is sought for changes which indicate a succession in the ecosystem of the field area."

As can be seen, this experiment is an intensive study of a selected habitat. Therefore, if a grade ten or eleven biology teacher wishes to reduce his regular course by six weeks and if he selects this laboratory block as a substitute then it could provide an opportunity for the teaching of ecology in the Alberta School System.

Research Problems in Biology-BSCS

> "The series of four volumes of Research Problems in Biology was initiated by the BSCS Special Student Committee, headed by Paul F. Brandwein. Each volume consists of 40 separate investigations, all prepared by active researchers in the area of the investigation. These represent problems that have some promise ofyielding results that are publishable, that are genuine contributions to science. Obviously they are directed toward only the highly motivated, creative high school student, and require persistent effort, often more than a year's time, to carry out."

The table of contents of these series classifies 24 of these as ecology problems (Table 17). Therefore this series does provide special students with an opportunity to study ecology.

CURRICULUM GUIDE REVIEWS

Each of the textbooks reviewed contained a different provision for the teaching of ecology. The sale of textbooks provided one index of the teachers' preference in textbooks. However, as stated previously, a teacher may not be using only that one textbook. Therefore the Guides were reviewed in an attempt to determine the actual provision for ecology and ecological projects in the Alberta Public School System.

Junior High School Science, 1969

This Guide does not provide a detailed course outline nor does it state a preference regarding recommended textbooks. In fact it states that "While several new series of textbooks have been recommended for use in Alberta Junior High Schools, it is strongly recommended that no one science series should be used to the exclusion of the others or other library reference materials". The teacher is left free to develop his own course within the guidelines of the general objectives of the course. These objectives are:

1. To develop student awareness of the humanistic and social implications of science.
2. To enable the student to better understand and appreciate the true nature of science.
3. To develop student attitudes that are in harmony with the spirit of scientific investigations and
4. To have the student develop basic science concepts.

Seven basic concepts are listed (Table 18) the third of which is often stated as being a definition for the science of ecology. Therefore the grade seven science course does provide an opportunity for the teaching of ecology in any form desired by the teacher. The amount actually taught depends upon the individual teacher and his selection of resource material.

Senior High School Biology, 1969

In contrast to the Junior High School Science Guide, this Guide does list the recommended textbooks in order of preference and does provide a course outline. The preferred text for Biology 10 (Grade 10) is High School Biology, BSCS Green Version while the course outline consists of four units one of which is specifically titled ecology (Table 19-A). However as indicated previously, if this text is used then the whole emphasis of the course will be ecological. The Guide also indicates that one complete unit consists of a student-selected biology project.

The preferred text for Biology 20 (Grade 11) is Biological Science: An Inquiry Into Life - BSCS Yellow version. As indicated in Table 19-B Unit One of the three possible units provides the student with an opportunity to investigate further principles of ecology by carrying out a field or laboratory project.

CAMROSE TEACHER INTERVIEWS

The information summarized in Table 20 indicates that the teachers interviewed varied greatly in training, experience and in duties. A total of 22 teachers were interviewed. Thirteen were classified as mainly teaching grade seven biology while nine were classified as teaching mainly grade 10 and 11 biology. Appoximately 1150 students were being taught biology by these teachers. The questionnaire (Appendix A) completed by these teachers should, therefore, provide a range of opinions regarding the use and value of ecological projects. The results of the interview questions will be discussed individually.

Questionnaire Results

Question 1. The answers to the question regarding the areas of biology in which students were or had conducted projects were varied. Some were one word answers, while others were detailed explanations of projects. The data were classified into the different areas of biology (Table 21).

The results indicate that projects were more often being conducted in the area of ecology and pollution than in any other area of biology.

Question 2. When asked, all of the teachers interviewed indicated the wish for additional resource oriented projects.

Question 3. The teachers when requested to indicate in which area of biology additional resource oriented projects were desired, indicated overwhelmingly that assistance was most desired in the field of ecology (Table 22).

Question 4. The teachers indicated that small group and individual student projects were preferred to entire class projects (Table 23). A slight preference for small group over individual projects was recorded.

Question 5. A slight difference of opinion was noted when the grade 7 and the grade 10-11 biology teachers were asked about how much of a project should be conducted in class time (Table 24). Grade 7 teachers' answers varied anywhere from 40 to 80 percent while grade 10-11 teachers' answers varied from 15 to 75 percent. However, the average percentage varied by only a few points; 62 percent for the former and 57 percent for the latter.

Question 6. Opinions regarding the amount of biology class time which should be devoted to ecology projects also varied according to grade level (Table 25). The grade seven teachers' opinions varied from 10 to 40 percent while the grade ten and eleven teachers' opinions varied from less than 10 percent to 50 percent. However, in both groups most teachers chose from 20 to 30 as being the desired percentage of time to be spent on ecology projects in a biology course.

Question 7. Projects were about equally desired for the fall and spring season, although some winter projects were considered desirable (Table 26).

Question 8. Exploring Life Science was the textbook most often listed as the main resource material in grade seven science, whereas the BSCS Green Version and Modern Biology were listed most often by the grade 10-11 biology teachers questioned (Table 27). Teachers were using a variety of resource materials to supplement and at times to replace the use of textbooks. This is indicated by the high percentage of material listed under the title "Other" even though teachers were specifically asked to list the textbooks used.

Question 9. The results from question nine were varied and difficult to summarize (Table 28). No answers, answers using only one word, and answers covering a number of paragraphs were given. However, the question was asked to allow teachers to express their opinions regarding successful or desired projects.

Additional Comments

The dictaphone recordings were not obtained in a sufficiently systematic manner to provide well documented data. However, as with Question 9 of the questionnaire, some of the remarks were helpful in determining the design of the ecological projects in this study. They were included for this reason. Each of the following unedited relevant remarks was recorded by a different teacher.

> "The only reference material we had was just what we could collect from the students and any that I could get hold of myself, or the encyclopedias available in the library. The reference material was quite limited for all of these projects."

> "Biology-ecology projects would be one of the better type of projects because I think they can go out and work on their own rather than have the teacher do most of it for them."

> "... they must be outlined though because to give these students a project and say go ahead - nothing would happen."

> "We have been given the opportunity to use projects but haven't got a clue of what kind of projects to do nor do any of our students. We require direction on this."

BOOK AND PROJECT DESIGN

A book of projects was written in an attempt to fulfill the need for resource material as expressed by the Camrose teachers. This book of projects consisted of two main sections. One section was to be used by the teacher only while the other was to be used by both student and teacher. This latter section was called the student's section. The teacher's section consisted of a table of contents, an introduction, two appendices and the main body of the text. The introduction briefly outlined the purpose of the book of projects and provided some suggested methods for its use. The main body of the text was divided into sections according to the phylogenetic position of the animals used for the projects. The information in each section varied to match the needs of the project. Therefore, some sections contained only factual material, i.e. life histories of animals, while others contained information related to expected results, pitfalls, techniques and additional ideas related to the projects. The information was kept brief. A section called "Seasonal Considerations" was later added to the information for each animal group.

Appendix A in the teacher's section was a cross-index of the problems in each project with the concepts and principles of ecology.

Teachers were told that they could use this appendix in two ways - as a check after completion of a project to determine whether the student has recognized potential concepts and principles, or as a guide to selecting a project. Selection could be based either on a teacher's wish to teach a certain concept or on the animals available. A short list of selected references chosen for Alberta teachers completed this section.

The student's section consisted of a table of contents, an introduction, the projects and an appendix. The table of contents listed all problems under the heading of animal groups. Therefore, a student or a teacher could select an animal for study and immediately be able to select a problem or a series of problems. The short introduction briefly explained the meaning of ecology, the purpose of the projects and the manner in which they could be used. This was followed by the projects *per se*. Each project consisted of a series of related problems all using the same animal group. Where applicable a section of general methods preceded the actual problems. This section generally contained collecting and culturing methods. Equipment needed was sometimes listed in the general methods section and sometimes included in the text. Sometimes methods of observation were also included in this section. The general methods sections were all written for the students keeping in mind the limitations imposed by equipment, techniques, and literature resources available.

The section containing the projects *per se* was entitled "Suggested Projects". It was felt that the student should feel free to accept or reject any part of the project. The problem statement and the designs were open-ended and were worded to encourage the discovery method of learning. The discovery method was further encouraged by the inclusion of a series of leading questions. These questions attempted to get the student to consider the experimental design of his project as well as the concepts and principles of ecology. A number of problems consisted only of questions so that students could be encouraged to develop their own experimental designs. The appendix in the student's section included techniques and equipment considered helpful to the student.

A section called "Winter Considerations" was added later to each animal group. Information of this type was requested by some teachers during the evaluation phase of the study.

PROJECT EVALUATION

Pilot Study Evaluation

Thirty-five teachers were judged to be eligible for the evaluative phase of this study; 26 of these were senior high school teachers of biology while 9 were grade seven science teachers. Seven additional grade seven teachers were contacted in a meeting of the Edmonton Public School Board Life Science Committee. These teachers received the material but did not promise to participate because of the late date of the receipt of the materials. None of these teachers did participate in the study. Twenty-seven of the 35 teachers returned the first evaluation questionnaire as promised. The second questionnaire, sent on June 7, 1972, was returned by 18 of the 27 teachers. Three of the 18 teachers combined their answers because of a team teaching situation. Therefore, the final pilot project sample size was reduced to 16 teachers; 11 senior high school teachers and 5 grade seven teachers. These 16 teachers represented 15 schools and 10 different school districts.

The results from the two pilot study evaluation questionnaires will be treated as follows. The results from questions one, two and three of Questionnaire #1 (Appendix C) will first be presented. All results of question four will then be presented. This will be followed by the presentation of questions one, two and three respectively of Questionnaire #2 (Appendix D).

Question 1 of Evaluation Questionnaire #1

The question was designed to obtain personal information regarding the classroom teachers involved in the study. The teachers interviewed varied greatly in training, experience and duties (Table 29). They, therefore, provided a range of opinions regarding the use and value of ecological projects.

Questions 2 and 3 of Evaluation Questionnaire #1

These questions were designed to determine the teacher's objectives with regard to biology and biology project teaching respectively. If the teacher regarded the teaching of facts and principles as the most important objective then he could not be included in this study.

None of the classroom teachers rated "knowledge about facts and principles" as the most important objective for biology project teaching. Sixty percent of the teachers rated it as the least important and 27% rated it as the second least important (Table 30).

The objective "Ability to utilize methods and attitudes to interpret scientific problems" was rated most important by 67% of the teachers and second most by 33% of the teachers. All teachers could, therefore, be accepted for this study.

Question 4 of Evaluation Questionnaire #1 and #2

The aim of question four was to determine if the writer's projects were an effective source of ideas for teachers.

Statistical analysis using the Wilcoxon's signed rank test as outlined by Steel and Torrie (1960), demonstrated that when all questions were considered the writer's projects were rated more effective at the 0.01 level than those previously used by the students (Table 31). No significant difference was noted in the cognitive domain but a significant difference in favor of the writer's projects was noted in the affective domain. With respect to the senior high school teachers only, (Table 32) the writer's projects were rated more effective at the 0.01 level in both the cognitive and affective domains. The greatest difference was noted in the affective domain. On the other hand, grade 7 teachers considered projects completed by students in the last two years to be much more effective than the writer's projects (Table 33). No significant difference was noted in the cognitive domain but a significant difference was noted in favor of the students' past projects in the affective domain.

Question 1 of Evaluation Questionnaire #2

This question allowed the teachers to check the parts of the project booklet which had been attempted. The results indicated that Evaluation Questionnaire #2 was based on the use of all parts of the projects provided, with the exception of the project involving pheasants and grouse. No part of this project was attempted. Altogether

277 students were involved with the projects, 141 of them from senior high schools and the remaining 136 from grade seven.

Question 2 of Evaluation Questionnaire #2

In this question the teachers were asked to rate the effectiveness of the project booklet(s) as teaching aids. All except two items in this question were rated "good" (Table 34). The two exceptions were that the booklets were considered "fair" as units by themselves and were considered "very good" as a source of ideas. The ratings indicate that no one section of the booklets were considered to be "poor".

Question 3 of Evaluation Questionnaire #2

This question asked for comments regarding the projects. Eleven teachers availed themselves of the opportunity to comment freely regarding the projects and the project booklets. Because each teacher views and uses material differently and because questions on questionnaires may restrict a teacher's true feelings all pertinent comments are included in this section. Each paragraph represents the comments of one teacher.

Grade 7

> "The projects were given out completely on a 'do if you like' basis. Very good interest was shown by the student, as most of the work was done by the students at home in the evenings."
>
> "Units are thought provoking. Gives students a chance to do something entirely by themselves. I would like to see each project in booklet form or portfolio form. Students would have a unit by selves."
>
> "The directions to the students were much too general and caused much confusion. It required much library research into the

topics before the student felt capable of carrying out the project."

"Like local emphasis and the fact that the instructions are detailed."

"The pupils following your project ideas did some very good research work. The final work was displayed at the 'science fair' and was viewed by visitors with much interest. The pupils enjoyed following your projects. The problems you listed for each proved a great help for each pupil to either work individually or with a group in doing his or her research."

Senior High School

"On a half semester course I found the projects took a lot of time, perhaps because they have not worked on their own too much before. Also their results were very poor; also I can blame myself in not going over the problems that might arise, beforehand. I think another time round, the kids could get much better results and dig more deeply into their projects."

"Most students encounter difficulty with setting controls for the high school level. They were interested in earthworms and ground squirrel projects but were worried about multiple factors influencing their data."

"I found the books very useful as far as giving me ideas for organizing projects. They served as excellent models for projects. After treating several projects in this fashion, I found I had 'caught on' to the idea behind such investigations, and made up a number of my own e.g. flower collections, comparing types of flowers found growing in different habitats, also comparing types of algae found in different water bodies e.g. puddles, horse troughs, sloughs, running water, etc. From this point of view, I found your work invaluable, and would like to see it expanded to include plant projects as well as animal projects."

"Generally the pollutant studies are extremely distasteful particularly when all animals die or seemingly painful behaviour is elicited. Projects are not experimental because results can be guessed. Many of the questions are at an elementary or junior high level. Some ideas okay, but most generally not too useful particularly since items such as culturing techniques have been readily available for a long time. We intend to include some of your projects into our program."

"Appendix too brief - a much wider range of problems is possible with the materials suggested. A pattern for preparing and presenting a project would help students."

> "Teachers' Manual - specific nature of this is refreshing and useful. This is a down-to-earth, realistic pair of manuals, that are 100% useful. The experiments have led students to other topics and seems to make them enthusiastic about their studies. Students didn't want much assistance from me, they were eager to be doing the experiments all by themselves, and answering the questions by themselves."

SUMMER SCHOOL EVALUATION

Nine students were enrolled in the summer school course, all of them teachers with teaching experience ranging from 1 to 16 years (average 6.3). Eight of the teachers had taken from five to more than eleven biology courses at the University level (average 6.4). The one exception had completed a graduate degree in French prior to becoming involved in biology teaching. She, however, had subsequently taken a number of short term courses in biology such as the BSCS short courses. The writer had an opportunity to discuss this lack of a formal biological background with a Science Consultant for the Department of Education, who assured me that the teacher was a competent and knowledgeable biology teacher. All of the teachers in this class were therefore considered able to judge the biological content and the effectiveness of the projects.

Teachers chose and conducted projects involving the following groups of animals: protozoans, hydras, earthworms, caddis flies, houseflies, ground squirrels, small mammals and beavers. The writer's outlines were given to the teacher(s) for the above. The problem section of the outlines only were given verbally to the teachers for the projects which were chosen using the following groups of animals: pond crustaceans, aquatic beetles, planarians, ants, snails and grasshoppers.

Questions 1 and 3 of Evaluation Questionnaire #3

Questions 1 and 3 were designed to evaluate respectively the project proposal or project outline and the learning resulting from the project. Question 2 dealt with the manner in which the project was handled and so the results were not applicable to this study. The summer school teachers rated the writer's project outlines as "very good" in the area of suitability, clarity and as a project (Table 35). The planned use of scientific methodology was rated as "good". The learning resulting from the projects conducted was rated as "good" (Table 35).

The above results were of course based only on the project outlines given to the teachers by the writer. Only the results for one item "Clarity of Problem Statement" were used where the ratings were based on projects completed as a result of the writer contributing the problem statement only. This item was rated as "very good" (4.4) on those evaluation sheets.

Question 4 of Evaluation Questionnaire #3

The projects were considered to be "very good" projects for individual students or small groups of students and "fair" projects for a whole class (Table 36). Fifty-seven percent of the projects were judged to be two week projects if conducted by the whole class, 86% were two week projects if conducted by small groups of students and 43 percent were two week projects if conducted by individual students. The majority of projects were considered to be two week to a month projects if used by small groups or individual students.

Forty-three percent of the projects were considered to be projects which could be conducted in all seasons while another 43 percent were considered to be applicable both to the fall and the spring seasons. Only 14 percent were judged to be limited to one season; namely spring.

The equipment necessary for 86 percent of the projects was considered to be easily available while the equipment necessary for 14 percent of the projects was considered to be available but difficult to obtain.

The techniques advocated for 86 percent of the projects were considered applicable while 71 percent of the literature resources were considered to be available and the remaining 29 percent were judged to be available but difficult to obtain.

1973 EVALUATION

The writer was informed that six high school biology teachers were teaching in the Yellowhead School District #12. All six were contacted on January 29, 30th, 1973 and all decided to participate in the study. Twenty-seven of the approximately 30 teachers who attended the Calgary Biology Teachers' Association meeting on Febuary 6, 1973 decided to participate in the study. Twenty-four teachers were contacted in the Peace River area. Three teachers did not wish to participate in the study thereby leaving 21 participating teachers in this area.

The three teachers who did not participate had asked for time to think about the projects. One simply returned the books without comment. The other two, both from the same school, categorically and emphatically stated that the books were absolutely useless.

Their statements can only be judged in the light of the results obtained with participating teachers. Therefore, a total of 54 teachers representing 40 different schools completed the 1973 Evaluation Questionnaire #1 (Appendix G).

All of the 54 teachers were again contacted in June, 1973. Forty-nine of these were visited by the writer, four were contacted by telephone, and one was visited by Mr. G. Gay, Department of Education, on behalf of the writer. All of the 54 teachers who had completed Questionnaire #1 prior to the use of the writer's materials provided the information requested.

Of these 54 teachers, 35 felt that they had had enough students try the writer's projects to allow them to complete the entire 1973 Evaluation Questionnaire #2. An additional 11 teachers felt confident enough to complete all of the questionnaire except question 3. The remaining eight teachers completed only questions 4 and 5 of the questionnaire.

Thirty-nine of these teachers sent in students' questionnaires. These questionnaires were sent from 35 different schools. Two hundred and eighty-four students completed the Student Questionnaire (Appendix I). These consisted of 130 grade ten students, 120 grade eleven students and 34 grade twelve students.

The results of the questionnaires will be treated as follows. The results from the Student's Questionnaire (Appendix I) will first be presented. The results of question 1 of the 1973 Evaluation Questionnaire #1 will be presented next and this will be followed by a comparison of question 2 of the 1973 Evaluation Questionnaire #1 and question 3 of the 1973 Evaluation Questionnaire #2.

Student's Questionnaire

Question 1 was designed to determine the animals and projects used by the students. Projects from 27 to 31 animal groups were attempted by the students. The only animal groups not attempted were the projects using aquatic bugs, etc., water mites, pheasants and grouse and pocket gophers. Students used a problem outline, a series of problem outlines, or a combination of culturing methods and parts of a problem outline. In short, the materials were used as a resource book and not as a laboratory outline.

Question 2 allowed the students to rate the projects as to interest, difficulty and adequacy of instructions. As indicated in Table 37 the students apparently felt that the projects did meet some objectives of this study. If all of the grades are considered together only four percent of the students stated that the projects attempted were not interesting, five percent indicated that they were very difficult and nine percent felt that the instructions were not adequate. The rest felt that the projects attempted were fairly interesting (59%) to very interesting (38%), fairly difficult (47%) to not difficult (48%), and that the instructions were fairly adequate (45%) to very adequate (46%). No great difference in opinions was noted between the grade levels.

Question 3 allowed the students to rate the effectiveness of the projects in helping them to understand four areas of science-biology listed. The answers (Table 38) appear to be skewed to the high end with the mode being in the "good" range.

Question 4 simply asked the students if they would like to do more projects of a similar nature. Eighty-five percent of the grade 10 students, 78 percent of the grade 11 students and 94 percent of the grade 12 students indicated that they would enjoy similar projects. Even though the negative reasons were in the minority some of these were quite interesting and provided indication of students' feelings toward projects. A sample of the negative comments and two representative positive comments are included below.

> "Yes - Because with the problem and procedure given the experiment was easily handled and all equipment and necessary supplies were given, therefore you could go about the necessary steps with ease."
>
> "Yes - When you see the animals in their natural environments it makes you realize and appreciate the importance of unspoiled nature."
>
> "No - Because I do not like doing projects of any kind."
>
> "No - Because the animals are too small to work with."
>
> "No - Not interested in this field."
>
> "No - This project was cruel and it is distressing to watch helpless creatures suffer when you can do something about it. It did, though, show the effects of pollution on these leeches. Makes you realize what is happening to our environment."

Question 1 of the 1973 Evaluation Questionnaire #1

The question was designed to obtain personal information regarding teachers involved in the study. The teachers varied in training, experience and duties (Table 39). No great difference in training, experience and duties was noted when the 35 teachers who completed the entire questionnaire #2 were compared with the 19 teachers who partially completed the questionnaire (Table 39). Attempts were also made to correlate the information given by the 35 teachers with differences in mean scores given on the 50 answers in question #2 and #3 respectively of evaluation questionnaires one and two. No definite relationship emerged from these attempts at correlation.

Question 2 and 3 of the 1973 Evaluation Questionnaire #1 and #2

These questions were designed to determine if the writer's projects could be as effective as other ecologically oriented resource projects. The answers were analyzed and compared by the use of a correlative t test, an analysis of variance. A computer program was used which computed means, standard deviations, correlations between questions within a questionnaire, t values for variances and t-test values for means. Attempts were made to determine some relationships between questions as determined by the answers. Even though many of the questions had correlations of 0.5, 0.6 and 0.7 no pattern was discernable when the answers on both questionnaires were considered.

T-test values for means which have a probability of occurring less than 5 percent and 1 percent of the time by chance, are listed in Table 40. The table can be summarized by stating that pilot study teachers rated the writer's projects as significantly (95 percent level) more effective as resource material then other materials on 15 of the 50 questions, while the 1973 teachers rated the writer's projects as significantly more effective at the 95 percent level than other resource materials. It should also be noted that none of the questions were rated significantly less effective than other materials and that only questions 14, 28, and 41 even produced a probability value in favor of other materials. The probability values for these questions were 0.1349, 0.3708 and 0.7296 respectively. Possible reasons for the scattering of the significant values throughout the cognitive and affective domains will be discussed later.

Question 1, 2, 4 and 5 of the 1973 Evaluation Questionnaire #2

Question one allowed the teachers to rate the effectiveness of the books of projects as a teaching aid. The 1973 results were divided into two groups and then combined (Table 41). The first group consisted of the 35 teachers who completed all of Evaluation Questionnaire #2 while the second group consisted of the 11 teachers who felt that their students had not had enough experience with the projects to enable them to complete question 3. As with the pilot study, all except two items in this question were rated "good". The two exceptions were again that the books were considered "fair" as units by themselves and were considered "very good" as a source of ideas.

Thirty teachers responded to the request for comments in question 2. The responses varied from a few lines to a five page letter. Because each teacher views and uses material differently and because questions on questionnaires may restrict a teacher's true feelings all pertinent comments are included in this section. Each paragraph represents the comments of one teacher.

> "If possible give season best suited for project and include a reference book for each project."
>
> "I think you are providing an important addition to environmental education in Alberta."
>
> "Page numbers would help. Although you have probably place emphasis upon projects involving a single species/population for very valid reasons - that is where we most desperately need project ideas - I was puzzled by the lack of studies involving more general analysis of larger ecological units."

"Very limited use of this manual was made. By the time I got the book, I had 3 groups that looked at it for ideas, only one chose to use an experimental project. I think that the manual is a good starter for many projects. There are many good project ideas which students are not aware of, however, most of these require early fall or early spring situations."

"A good source of ideas - manual for student rather too basic for the Biology 30 projects. Received too late, therefore, the 'top' students did not use the manual."

"Teacher's manual is a very good source of information. I found that some of the projects could not be attempted this semester (winter) because the specimens could not be obtained. Some students tried projects from the red books, several of them got ideas from them but modified them to their own purposes (i.e., they got ideas from the titles of the projects, made up their own experiments.)"

"Test sample from this school was smaller than I thought it would be - partly due to us being well into the projects by February (started them in September) so only those looking for another one or late arrivals were involved."

"Very few students chose to do the project as laid out but used them for ideas in setting up their own project on the same topic - e.g. Ants, Beaver, Starlings, etc."

"Four students, two pairs, attempted projects from your guides. I believe this was due to your projects dealing with animals. Our facilities for the care of animals are not that good."

"The biggest problem is to get students to do any project. This year I'm going to give the student a choice as to what they can do based on these texts."

"Based on time of year (winter) many students were reluctant to attempt the projects. Many, however, did look at various projects for ideas and types of procedures that should be followed in a project."

"I found most topics were rather ambiguous. As a topic suggestion they were good. Lacks any real direction which it seems is what students want. I realize a student should use his or her own creativeness and imaginative ability but students don't seem to realize this."

"Pages should be numbered. Students used these books as a source for project ideas and then wrote up a formal project proposal."

"Books were used mainly for source of project ideas, and as such were excellent."

"No page numbers. Some ideas in the teacher's manual are not clarified fully. I think project dealing with identification could have been stressed more. The pollution aspects are very time-consuming and instructions vague at times. These books were definitely a guideline for many ideas but most students preferred not to have a definite outline at first. Protozoan projects very good."

"The problems stated in the student's manual should be detailed enough to ensure clarity. Many students had trouble interpreting the exact nature of the problem *per se*."

"Projects done - Earthworms - 2 different projects. Beaver Pond - best project of all my grade 11's - very well done and the student was very interested in the work. Ant colony."

"Page numbers required - unsuitability of projects due to weather conditions - good source of ideas."

"More specific directions for culturing, and collecting should have been given."

"Page numbers required. The students who made use of the project books got results which were much superior to those who didn't. The book seems to provide the students, not only with ideas for projects, but also with guidance."

"Biology 10 and 20 are only 3 credits each. Projects are only a unit of each of these courses. The work load for students and teachers is always related to credits earned or taught. Most projects formulated in most sources are a moderate amount of work for a good student, and a lot of work for the students that aren't so capable."

"Being a Northern school teacher, my main problem was a lack of ideas for different projects to be done by the class. These books helped solve this to some degree although I got them quite late in the year when most of the students had already started their projects."

"I think there should be more structure to some of the projects. Recently many teachers have been using open ended teaching methods but I still think that in most schools teachers prefer organized projects."

"Most projects were very well organized and the questions asked were pertinent ones. Some of the animals suggested are difficult to collect in our area and difficult to culture, thus limiting the use of the books somewhat but not a serious drawback."

"Excellent - prevented pupils from working into dead ends - got pupils into the field and involved in actual firsthand observations - pleasant change from verbatim library reports."

"Interesting - well designed information presented simply but exactly. Will probably use some of the projects for junior high option course."

"Good as supplement or supplemented by other sources. Being the first try to involve students in projects with live organisms, it was not a very great success, but I am sure, we can do much better next year."

"Pages should be numbered. Next semester projects from this source will be tied in with various units in the Bio. 10 course through use of the cross reference."

"Projects were very good .... project on the frog sounds was particularly good."

"Teachers manual a very valuable aid. I obtained many ideas for mini-lessons to use in biology classes as interest lessons developed by discussions, (how to observe birds and large animals), lectures (collecting, culturing) and by a combination of both. Student's manual excellent."

Question 4 was designed to determine why the writer's projects were not used. All 16 teachers who did not complete question three of Questionnaire #2 were considered in this group. Eighteen percent checked the reason for not using the material as lack of time, 56 percent indicated that students had chosen their own projects and 26 percent indicated that projects were not suitable this semester. When these teachers were asked if they anticipated making greater use of the material next year, (Question 5), 75 percent indicated that they did anticipate greater use while the remaining 25 percent were not sure. Fifteen of the teachers provided comments indicating why projects were not used. These are included below. Each paragraph represents the comments of one teacher.

> "We had difficulty obtaining organisms because of budget and time."
>
> "Did not have time to use them because of the course structure (3 credit course)."
>
> "The class was Biology 30 and students had projects already picked; many were extensions of their Biology 10 and 20 projects."
>
> "Students were offered the option of using a project as outlined in the book. All students who were offered the use of the book rejected it. Their primary reason appeared to be interest."
>
> "Students worked on plant projects over animal experimentation for unknown reason this semester. Perhaps difficulty in handling animals or the fact that plant projects received the highest marks last semester."
>
> "Biology 30 - most projects were on human physiology."
>
> "Lack of specimens because of time of year and or not provided for in the budget. Lack of familiarity on my part, type of specimens used in certain of the projects."
>
> "Not enough time was available this semester to organize these projects for the students use."
>
> "I am far from satisfied with my pupils' attitude towards projects. They want to select topics that they can WRITE volumes on. They do not want to do field work."
>
> "The projects were suitable for my students, however, they were given their choice for the topic and none of yours were chosen."
>
> "Students chose their own projects. Those that looked at the books were the lower ability group that have difficulty in choosing, running experiments, lack motivation and/or interest in the subject possibility. Hence any projects seem to be a 'bore'."
>
> "Students had chosen their projects in advance of receiving the books."
>
> "Our use of these worthwhile books was very limited because students, for the most part, had committed themselves to a project before the books were available. Students did show an interest and made use of information contained in the books - techniques and appendices."

"Students had completed most of the project studies prior to receiving this set of projects."

"I was only able to get one student interested in doing one of these projects. The projects are too simple for Biology 30 level students. No page numbers resulted in students not looking through the books."

Question 5 was included to determine if teachers anticipated a greater use of the materials in the future. Seventy-five percent of the 16 teachers who made very little use of the materials this year said they did anticipate greater use. Seventy-one percent of the 35 teachers who did make use of the materials also indicated that they anticipated greater use next year while 11 percent were not sure and the remaining 18 percent did not answer the question.

DISCUSSION OF THE RESULTS

The terms of reference of this study excluded one factor which must be considered in order to place the results in perspective, namely, teachers' and students' attitudes towards experimental projects. The study assumed that every teacher agreed with the suggestion by the Department of Education that every secondary biology student should conduct a laboratory or field research project. However, I encountered many teachers who questioned this suggestion and stated that some students were not interested in, or capable of, conducting any project, let alone an experimental project (page 56). I was often also asked to review and comment on reports of previously completed projects and discovered that only about 10 to 20 percent of those reviewed were experimental. The rest of the projects were written library reports. The small percentage of experimental projects was often attributed by teachers to student's attitudes towards projects (page 59). Some supportive evidence for the teachers' statements is found in the students' comments reported on page 53.

This study revealed another possible reason for this alleged negative attitude, namely, insufficient guidance. The response to experimental projects was very positive when students were given guidance, i.e. my materials. The large percentage of students who indicated that they would enjoy doing another experimental project supports this statement.

The summer school teachers in this study provided some indication that the negative reaction to experimental projects may also be attributable to teachers' attitudes. Some of these teachers were very concerned about getting the "right answer" when conducting their projects. In education terminology they appeared to be more concerned about the "product" than about the "process". This attitude would appear to result in a bias toward written library reports and against the uncertain experimental approach to projects. The manner in which my projects were handled would appear also to bias students toward written library reports. For example, a common problem encountered during collection of completed questionnaires was that many teachers, 35 of the 54 in the Peace River area, allowed their students to work on projects up to the last day of the school term. It is, therefore, obvious that the projects were not discussed but were simply given a mark based on the written report. The "product" not the "process" then became the basis for the mark. This method of handling the projects might be the reason why my projects were considered to be no more effective than other materials used in helping to teach students about the connection between ecology and social action, (questions 28, 36 and 41, Table 40). I assumed that the social implications of the projects would be discussed during their presentation. Students were asked leading questions and teachers were given information to assist in this discussion. However, it appears that most students had no opportunity to discuss their completed projects.

Considering these predominantly negative attitudes on the part of some teachers and students to experimental projects, the possible bias in favor of written library reports and the rather short lead-time given to the teachers, the generally positive response expressed in the results suggests that the project outlines fulfilled a real need. However, the study did have shortcomings and difficulties which are discussed below.

1. The cooperating teachers were not a randomly selected sample of Alberta teachers. If a random sample had been used, time and distance restrictions would have necessitated sampling by mail. Mail sampling may have resulted in a high proportion of non-cooperators. Attempts were made to avoid a bias in sampling by including whole sub-populations, i.e. all secondary biology teachers in the City of Camrose S.D. #1315, Camrose S.D. #22, Yellowhead S.D. #12 and Peace River Area #1. It could be argued that the Calgary teachers are a biased sample if one assumes that those who attend meetings are more interested in doing a good job than those who do not. On the other hand a higher dropout rate from the sample of Calgary teachers then among other sub-populations probably indicates that the sample was not strongly biased. Since the Edmonton teachers were chosen by a hit or miss method they could be biased. However, the results from these teachers agreed in general with those other sub-samples. Therefore, it can be concluded that the teachers in the sample were likely representative even though they were not chosen by a statistically random process.

2. A major shortcoming of this study was that the materials were given to the teachers in the middle of a school term. Some of the remarks recorded on pages 56 to 60 and the responses to

question five of the 1973 Evaluation Questionnaire #2 indicate that much greater use of the materials would have been made if the teachers had had more preparation time. I feel that, ideally, the materials should have been introduced, discussed and attempted by teachers in workshops for a year before being introduced into classrooms. This should have been followed by evaluation and revision over a period of several years.

3. The usefulness of the materials to grade seven students requires more testing. Conflicts of opinion regarding the usefulness of the materials for this grade can be seen in Tables 33 and 34. One of the five teachers who commented on the books also registered a negative opinion (page 46). Some reasons for the apparent conflict might have been the small sample size of teachers or deficiencies in the evaluation questionnaire used.

4. One of the main difficulties in this study is common to much educational research, namely, the problem of obtaining statistically valid data when dealing with humans as subjects of research. The number of uncontrollable variables associated with this evaluation compounded the difficulty. It would have been desirable to obtain quantitative data regarding the effectiveness of these projects by halving a classroom of students and assigning a set number of my projects to one group and a set number of other projects to a second similar group. Teachers' biases in regard to experimental projects could also have been evaluated in this type of situation. A division of this kind would have been

desirable from the experimental point of view but was impossible under the rules governing project teaching in Alberta.

5. The pollution projects *per se* were criticized by some teachers (pages 47, 57). One student's comment (page 53) illustrates the inherent dilemma with pollution projects. The projects are designed to reflect the real life situation. They could be changed so that the experiment could be stopped as soon as a behavior change is recorded. It is debatable whether this would be desirable from an educational or environmental point of view. Pollution does kill animal life and I feel that any attempt to conceal this fact would only dilute the message which would, therefore, dilute the concern for protection of the environment which might otherwise have been generated by the projects.

The lack of a statistically positive response to questions 33, 39 and 40 (Table 40) might also be interpreted as a criticism of the pollution projects. The reason for the response to question 33 might fall into the same category as discussed above, however, the response recorded in questions 39 and 40 might reflect a different problem. My materials stressed the ecology-pollution connection in the question section of the student's project outline and in the information section of the teacher's materials. Therefore, this connection would not have been emphasized if the students were not given an opportunity to discuss their projects. It is again a question of whether the materials should be changed to conform with the manner in which many projects are handled in the schools or whether the manner in which the projects are handled is at fault?

6. Teachers' written responses covered a wide spectrum from those who thought the information was detailed enough or even too specific (five teachers, pages 47, 48, 57, 58) to those who thought the information was too general or too vague (five teachers, pages 46, 57). The breadth of the response tends to support the conclusion reached in paragraph #1 that the sample was indeed representative of Alberta teachers. It also indicates that the objective of preparing useful material for the average Alberta teacher was achieved.

SUMMARY AND CONCLUSIONS

The following conclusions seem warranted.

1. There is provision for the teaching of ecology in grades seven, ten, eleven and twelve in the province of Alberta.

2. Teachers in Alberta appeared to want assistance in designing ecological projects.

3. Teachers expressed a preference for small group and individual student projects over entire class projects, fall and spring projects over winter projects, and projects requiring readily available equipment, simple techniques and a minimum of literature resources.

4. A book of ecological projects was written and tested in 45 classrooms by 57 senior high school biology teachers and at least 425 senior high school students. The projects were used in some of the largest urban senior high schools and some of the smallest rural northern senior high schools. Pre- and post-use teacher and student questionnaires were used to evaluate the materials.

5. Results of the student's questionnaire indicates that the majority of students found the projects to be interesting, not too difficult, and the instructions adequate. The majority again indicated that the projects were effective in helping them to understand ecological relationships, the problem of pollution and the diversity and identification of local animals.

6. The results of the teacher's questionnaires indicated that the

projects were acceptable to senior high school teachers and that they could be used successfully to meet the objectives of secondary school biology as set out in curriculum guides in the Province of Alberta.

7. Judgment regarding the acceptability and suitability of the projects for the grade seven level had to be reserved pending further evaluation.

Recommendations for Further Study

The study revealed a number of problems for further investigation. A larger and more comprehensive survey of Alberta teachers might yield more information regarding the use of projects and especially the use of experimental projects. Such a study could include thorough analysis of teachers' and students' attitudes to projects, the manner in which projects are assigned, conducted and evaluated, the type of projects being conducted and the reasons why certain types of of projects are chosen. The study should also attempt to determine if there is any correlation between the training, experience and attitude of a teacher and the types of projects being conducted in his classroom.

A study similar to this one should be conducted to include plants and microorganisms. Experimental projects should be designed and tested in the classroom by individuals competent in those fields. It would seem that many of the problems encountered with the pollution projects in this study could be avoided if plants were used for similar types of projects, for example, the effect of SO_2 on lichens.

The materials which have been developed should be periodically reviewed and updated so as to improve the experimental procedures and the usefulness to the Alberta classroom teacher. Finally, classroom teachers should be made aware of the existence of this material. Some possible methods of achieving this objective are listed.

1. The projects could be bound as a book and advertised in a similar manner as other textbooks. A commercial publisher or possibly the Extension Departments at some Alberta Universities could use this method.

2. The official organ of the Alberta Teacher's Association might be persuaded to publish a series of articles on biology projects, emphasizing the problems and materials available.

3. The Department of Education might see fit to publish a special bulletin on projects.

4. The Correspondence School Branch could use some of the writer's projects as part of their biology curriculum and could advertise the availability of the remainder.

5. School districts could hold a series of biology project workshops. This method would appear to be the most effective means of getting teachers to understand and appreciate the project method of teaching and materials available.

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TABLES

Table 1. The number of relevant science and biology textbooks sold by the School Book Branch in the Province of Alberta in the school year 1969-70

	Total
Grade 7	
1. Thurber, W.A., and R.E. Kilburn. Exploring Life Science. Macmillan of Canada. 1969.	10,813
2. Nuffield Foundation, Text 1-Introducing Living Things. Longmans, Green and Co. Ltd., London, 1968.	4,240
3. Nuffield Foundation, Text 2-Life and Living Processes. Longmans, Green and Co. Ltd., London, 1968.	3,938
Grade 8	
1. Secondary School Science Projects. Time, Space and Matter, Princeton Project. McGraw-Hill, Toronto.	16,197
2. Thurber, W. A., and R. E. Kilburn. Exploring Earth Science. Macmillan of Canada, 1969.	9,005
Grade 9	
1. Thurber, W. A. and R. E. Kilburn. Exploring Physical Science. Macmillan of Canada, 1969.	6,225
2. Marean, J. H. and E. W. Ledbetter. Physical Science: A Laboratory Approach. Addison-Wesley, Menlo Park, Calif. (c1968).	4,053
3. Hogg, J. C. and J. B. Cross. Basic Physical Science. D. van Nostrand Toronto, (c1960).	1,949
Grade 10-11	
1. BSCS Green Version, High School Biology, (2nd ed.), Gage, Scarborough, Ontario, 1968.	10,565
2. BSCS Yellow Version, Biological Science: An Inquiry into Life, (2nd ed.) Longman, Don Mills, Ontario, 1968.	7,416
3. Otto, J. H., and Towle A., Modern Biology Holt, Rinehart and Winston, Toronto, 1965.	2,193

Table 2. Table of contents of the textbook Exploring Life Science Thurber, W. A., and R. E. Kilburn. Macmillan of Canada, 1969.

	Page
HOW TO DO FIELD RESEARCH	8
PLANT AND ANIMAL COMMUNITIES	17
STUDYING INSECTS	49
SEASONAL BEHAVIOR	81
MICRO-ORGANISMS	113
CHEMISTRY OF COMMON FOODS	145
SUPPLYING OUR CELLS	177
RESPIRATION	209
HOW LIFE CONTINUES	241
OUR SENSES	273
MECHANISMS OF BEHAVIOR	305
THE GROWTH OF PLANTS	337
HOW GREEN PLANTS MAKE FOOD	369
GROUPING PLANTS AND ANIMALS	401
MAN AND HIS ENVIRONMENT	433
Appendix	465
Glossary	481
Bibliography	485
Index	489

Table 3. Headings in the unit "Plant and Animal Communities" in the textbook, Exploring Life Science, Thurber, W. A., and R. E. Kilburn.

	Page
Harmful Relationships	18
Competition	18
Grazers and Predators	19
Parasitism	20
Parasites of Plants	20
Parasites of Animals	21
Microscopic Parasites	21
Commensalism	22
Beneficial Relationships	23
Mutualism	23
Required Mutualism	23
Lichen Communities	24
Nitrogen Fixation	24
Saprophytes	25
Scavengers	26
General Energy Relationships	26
The Carbon Cycle	28
The Oxygen Cycle	28
Cycles in Aquatic Communities	28
The Nitrogen Cycle	29
Analyzing a Community	30
Quadrat Sampling	30
Quadrat Analysis	31
Strip Sampling	32
Using a Strip Sample	32
Sectioning	33
Changes in Communities	34
Succession	34
Fallow Field Succession	34
Bare Rock Succession	36
Climax	38
Forest Climaxes	38
Succession in Ponds	40
Animals in Plant Successions	41
Effects of Animals on Succession	42

Table 4. Examples of "Independent Investigations" selected from the two sections "Experimental Research" and "Other Investigations and Projects" presented in the unit on "Plant and Animal Communities" in the textbook Exploring Life Science.

Experimental Research

1. Sample of strip across a pond to nearby high land, identify the plant zones, and prepare a profile of the strip. Speculate about the history of the pond and predict its future.

4. Make a census of the birds and mammals on a section of grassland. List these according to their type of food, whether predators, grazers, or scavengers. Make a chart that shows their relationships to each other and to the plants.

8. Collect a few of the round growths from the roots of a clover plant. Crush one of the growths in a drop of water on a microscope slide. Note the colour of the interior of the growth. Examine a bit of the crushed material with a high-power lens for nitrogen-fixing bacteria.

12. Analyze the population of a region which has been swept by fire and compare it with a region which has not been burned.

Other Investigations and Projects

1. Report on how certain song birds reduce competition by setting up nesting territories.

4. Investigate the manner by which the green plant called mistletoe obtains its food.

8. Make a set of charts that shows the carbon cycle, the oxygen cycle, and the nitrogen cycle.

12. Make a collection of different kinds of lichens and exhibit them together with a chart that tells their life story.

16. Prepare a minature museum exhibit of a natural community using a box for the case with paper cut-outs or dried specimens to represent the organisms in the community.

Table 5. Examples of "Review" and "Thought" questions selected from the unit "Plant and Animal Communities" in the textbook Exploring Life Science.

Review Questions

1. What is a natural community?

4. What is a parasite?

8. What changes may take place in this pond during the next few thousand years if man does not change the succession?

12. Why are saprophytes of such great importance in a community?

Thought Questions

1. How might a natural community become established on an island that has been newly formed by volcanic action?

4. Why do lichens and small seed-bearing plants make up the climax community on the mountain peak shown on this page?

Table 6. Titles of chapters of the Nuffield series biology textbooks

TEXT 1

The variety of life
Investigating living things
Naming living things
Cells as units of life
How living things began
Reproduction and development in animals and man
Living things multiply
Finding out about locusts
Finding out about other insects

TEXT 11

Man and microbes
Growing bacteria
Bacteria and health
Man against disease
Shapes, sizes, and movements
Size and surface in living things
Movement in animals and plants
How plants reproduce
Growing up
Man and his environment

TEXT 111

Breathing: an exchange of gases
How breathing takes place
Respiration: how is energy obtained
Food and life
How animals feed
Problems of digestion
Plants and the atmosphere
Plants and light energy
The organism and water
The uneven distribution of organisms
Reaching the habitat-organisms which are moved
Reaching the habitat-organisms which move

TEXT 1V

Becoming established in a habitat
Community and succession
A community in the soil

Table 6. (continued)

Cells and water
The control of water content
Substances in solution
Transport systems in animals
Mass-flow systems in plants
Organisms "behave"
Structures which "do" things
Detecting changes in the environment
Linking systems
Adjustment
An important "adjustment" organ; the kidney
Behaviour and survival
Climax and feeding
How some living organisms provide habitats for others
How man may affect his surroundings

TEXT V

Similarities and differences in living things
How do similarities and differences come about
The material of inheritance
The origin of characteristics
How do genes work?
Development
Patterns of development
Problems of development
Different ways of breeding
Genes in populations
The selection of new generation
Evolution

Table 7. BSCS committee objectives in high school biology teaching
Source: Teacher's Guide, 2nd. ed., 1969

1. An understanding of the nature of scientific inquiry: Science is an open-ended intellectual activity, and what is presently "known" or believed is subject to change at any time.
2. An understanding of the limitations of science and scientific method: Some problems of great importance cannot be dealt with scientifically.
3. An understanding of the diversity of life and the interrelations of all organisms.
4. An appreciation of the beauty, drama and tragedy of the living world.
5. An understanding of the biological bases of problems in medicine, public health, agriculture, and conservation.
6. An understanding of the historical development of the biological concepts and their dependence upon the nature of the society and technology of each age.
7. An understanding of man's own place in nature: namely, that he is a living organism, that he has much in common with other organisms, and that he interacts with all organisms in the biological system of the earth.

Table 8. Unifying themes upon which the BSCS content is based
Source: Teacher's Guide, 2nd. ed., 1969.

1. Science as Inquiry.
2. Change of Living Things through Time: Evolution.
3. Regulation and Homeostasis: Preservation of Life in the Face of Change.
4. Diversity of Type and Unity of Pattern in Living Things
5. The Complementarity of Organisms and Environment
6. The Complementarity of Structure and Function
7. The Genetic Continuity of Life
8. The Biological Roots of Behavior
9. The History of Biological Concepts

Table 9. The levels of biological organization as used in the BSCS materials

1. The Molecular Level
2. The Cellular Level
3. Organ and Tissue
4. The Organism as an Individual
5. The Population
6. The Community
7. World Biome

Table 10. Table of contents of the BSCS Green Version, High School Biology

	Page
Section One: The World of Life: The Biosphere	1
Chapter 1 The Web of Life	2
Chapter 2 Individuals and Populations	36
Chapter 3 Communities and Ecosystems	72
Section Two: Diversity Among Living Things	102
Chapter 4 Animals	104
Chapter 5 Plants	153
Chapter 6 Protists	186
Section Three: Patterns in the Biosphere	214
Chapter 7 Patterns of Life in the Microscopic World	216
Chapter 8 Patterns of Life on Land	250
Chapter 9 Patterns of Life in the Water	305
Chapter 10 Patterns of Life in the Past	339
Section Four: Within the Individual Organism	376
Chapter 11 The Cell	378
Chapter 12 Bioenergetics	407
Chapter 13 The Functioning Plant	443
Chapter 14 The Functioning Animal	447
Chapter 15 Behavior	535
Section Five: Continuity of the Biosphere	576
Chapter 16 Reproduction	578
Chapter 17 Heredity	624
Chapter 18 Evolution	673
Section Six: Man and the Biosphere	714
Chapter 19 The Human Animal	716
Chapter 20 Man in the Web of Life	741

Table 11. Headings in the chapter "Communities and Ecosystems" in the textbook *High School Biology*, BSCS Green Version (2nd ed.)

	Page
The Ecological Viewpoint	72
The Biotic Community	72
The Concept	73
An Example	73
Investigation 3.1 - Study of a Biotic Community	76
Community Structure	83
Kinds of Ecological Relationships	84
Predation	84
Parasitism	85
Difficulties	85
Benefit one-harm to another	85
Commensalism	87
Mutualism	87
Competition	88
Evaluating Relationships	88
Species Structure of Communities	90
Structure in Depth	91
Community Boundaries	91
Structure through Time: Succession	92
Ecosystems	94
The Study of Ecosystems	94
Effects of Organisms on the Abiotic Environment	94
Ecological Niches	96
Continuity of the Ecosystems	97
Investigation 3.2 - Abiotic Environment: A Comparative Study	98
Guide Questions	100
Problems	100
Suggested Readings	101

Table 12. Examples of materials presented at the end of the chapter on "Communities and Ecosystems" in the textbook High School Biology, BSCS Green Version, (2nd ed.)

GUIDE QUESTIONS

1. What is meant by the statement "No organism lives alone"?

4. A predator is a factor in determining the population density of the species it eats, but a saprovore is not. Explain.

8. How is the number of species in a community related to its stability?

12. What are some ways in which man has changed ecosystems?

PROBLEMS

1. Rivers that run underground through caves (as in Kentucky) contain communities consisting of a few species, none of which are producers. Explain why producers are lacking and how a community exists without them.

4. Compare the system of biological energy in a cave community with that in a deep-sea community and with that in a city community.

SUGGESTED READINGS

1. Bates, M. The Forest and the Sea. New York: Random House, Inc., 1960. Chapter 10. (As good a statement of the biological community as can be made in 13 pages. Rather easy, but don't glide over the important points.)

4. Leshan, E., et al. "Sabino Grove Ecology Study", Natural History, May, 1965. Pp. 14 - 23. (Report of a study made by high school students in California.)

8. Swan, L. W. "The Ecology of the High Himalayas", Scientific American, October, 1961. Pp. 68-78.

Table 13. Examples of materials presented in the Teacher's Guide concerning the chapter on "Communities and Ecosystems" in the textbook High School Biology, BSCS Green Version, 2nd. ed.)

ADDITIONAL PROBLEMS

1. The frontier farm is often said to have been self-sufficient. What does this mean in terms of biotic communities?

4. "Pheasants eat several kinds of fleshy fruits. The seeds of these fruits pass through the digestive tract and are distributed throughout the countryside, and surprisingly, are better able to germinate than seeds that have not been eaten by pheasants."
Discuss the interrelationships illustrated by this quotation and formulate an experiment that might help classify the type of interspecies relationship.

ADDITIONAL INVESTIGATION

Competition Between Two Species of Plants

Table 14. Table of contents of the textbook Biological Science: An Inquiry Into Life, BSCS Yellow Version (Part headings only for the first three parts, part and chapter headings for part four.)

		Page
Part 1	Unity	1
Part 2	Diversity	177
Part 3	Continuity	521
Part 4	Interaction	645
Chapter 35	Animal Behavior	645
Chapter 36	Checks and Balances in Nature	677
Chapter 37	A World of Ecosystems	708
Chapter 38	Mankind: A Population out of Balance	734
Chapter 39	A Perspective of Time and Life-Molecules to Man	757

Table 15. Table of contents of the textbook *Modern Biology* (Unit headings only for the first seven units, unit and chapter headings for unit eight.)

		Page
Unit one	The Nature of Life	1
Unit two	The Continuity of Life	115
Unit three	Microbiology	211
Unit four	Multicellular Plants	293
Unit five	Biology of the Invertebrates	373
Unit six	Biology of the Vertebrates	451
Unit seven	The Biology of Man	541
Unit eight	Ecological Relationships	659
Chapter 48:	Introduction to Ecology	660
Chapter 49:	The Habitat	672
Chapter 50:	Periodic Changes in the Environment	685
Chapter 51:	Biogeography	699
Chapter 52:	Soil and Water Conservation	712
Chapter 53:	Forest and Wildlife Conservation	723
	Appendix	743
	Glossary	755
	Index	774

Table 16. Titles of BSCS Laboratory Blocks

1. Animal Growth and Development
2. The Complementarity of Structure and Function
3. Plant Growth and Development
4. Field Ecology
5. Microbes: Their Growth, Nutrition, and Interaction
6. Regulation in Plants by Hormones: A Study in Experimental Design
7. Life in the Soil
8. Animal Behavior
9. Genetic Continuity
10. Molecular Basis of Metabolism
11. Physiological Adaptation
12. Evolution
13. Radiation and its Biological Effects

Table 17. Ecology titles in the BSCS series *Research Problems in Biology*.

Series 1.

5. The Influence of Nonparasitic Nematodes on Plant Growth, Glenn B. Bergeson.
13. Effects of Flooding on Seedlings of Upland Tree Species, Edward Flaccus.
27. The Association of Subterranean Termites and Fungi: Mutualistic or Environmental, Anders E. Lund.
33. Analysis of Bird Territory, Thomas G. Overmire.

Series 2.

42. The Role of Light and Temperature in the Seasonal Distribution of Microcrustacea, Kenneth B. Armitage.
51. Suspended Sediment as a Factor in the Ecology of the Marine Snail *Urosalpinx cinerea*, Melbourne R. Carriker.
55. The Seed Coat as a Possible Source of Predaceous Nematode-Capturing Fungi, William A. Feder.
60. Investigation of Possible Interactions between Algae and Bacteria during Growth, Raymond W. Holton.
62. Secondary Succession, Germain E. LaRoche.
65. Similar Species in Similar Environments, John A. Moore.

Series 3.

86. A Study of the Fauna in the Soil, Paul F. Basch
94. Population of Milkweed Beetles, Richard A. Edgren.
96. The Soil Microflora and Growth of Conifer Seeds, Charles L. Fergus.
100. Intraspecific Variation in Plant Phenology, Elizabeth F. Gilbert.
116. Measurement of Radioactivity in Plant Leaf Ash, Jacob Verdiun.
117. Ecology of Attached Bacteria in Water, R. H. Weaver.
120. Variations in the Morphology of the Respiratory Organs of Aquatic Insects, Robert G. Wetzel.

Series 4.

121. The Life History of a Plant, Alan A. Beetle.
123. Pathogenic Fungi in the Plant Root Rhizosphere, C. W. Boothroyd.
128. Genotypic Response of Plant Species to Mineral Nutritional Factors, Emanuel Epstein and Jack Major.
137. Local Floras, Duane Isely.
143. Pollen Analysis of Animal Dung in Paleoecology, Paul S. Martin
148. Competition between Carpet Beetles, David Pimentel.
155. The Toxicity of Synthetic Detergents on Fish, William F. Sigler.

Table 18. Concepts to be developed in the grade seven science course as listed in the Curriculum Guide for Junior High School Science, 1969. Alberta Department of Education.

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1. Many living organisms are distributed and occupy many environments. Plants and animals are adapted and distributed in relation to geographic and environmental factors.

2. Diverse plants and animals may be classified into groups which have definite characteristics.

3. All living things interact with and are interdependent with each other and their environment.

4. Cells are the unit of structure and function of most living things.

5. Living organisms carry on fundamental processes to sustain life.

6. The fundamental theories of heredity and evolution explain the continuity of life and the wide variations in organisms.

7. Man has changed and continues to change the environment and the distribution of organisms.

Table 19-A. Course outline headings in the 1969 Curriculum Guide for Biology 10 (Grade 10). Alberta Department of Education

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Unit I Student Biology Project

This project will be guided by the teacher but will be selected and carried out by the student (or group of students). The project can be in any area of biology but should involve laboratory and/or field research and the writing of a report. It will be started early, will run concurrently with other units and may continue until the end of the course.

Unit II Classification

1. Basis of classification
2. Collecting
3. Preserving specimens
4. How to make and use a key.

Unit III Ecology

1. Ecosystems and communities
2. Environmental factors
3. Interaction
4. Resource management with emphasis on pollution and conservation
5. Space biology.

Unit IV Cell Theory and Genetics

1. Cell theory
2. Mitosis and meiosis (chemistry not included)
3. Mutation and selection
4. Selective breeding (Plant and animal)
5. Human overpopulation.

Table 19-B. Course outline headings in the 1969 Curriculum Guide to Biology 20 (Grade 11), Alberta Department of Education

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Unit I Student Ecology Project

This project will be guided by the teacher but will be selected and carried out by the student (or group of students). The project can be in any area of ecology but should involve laboratory and/or field research and the writing of a report. It will be started early, will run concurrently with other units and may continue until the end of the course.

Unit II Evolutionary Development

1. Review Unit IV, part 3 of Biology 10
2. The theories of evolution

Unit III Biological Kingdoms

1. The two, three and four kingdom systems
2. The relationship of form and function in the study of comparative anatomy, morphology and life cycles of selected representatives of the kingdom.

Table 20. Personal information regarding the Camrose teachers interviewed.

	Range	Average	Total
Years of University	1-5	3.5	
Major field of training (percent of total teachers)			
a. biology			40%
b. other			60%
Number of biology or related courses taken during the training	0-19	2.8	
Years of teaching experience	2-32	12.7	
Years of teaching:			
a. a biology course	0-26	6	
b. a course related to biology	0-31	11	
Percent of duties connected with teaching biology	10-100	33	

Table 21. Areas of biology in which Camrose students were conducting, or had recently conducted projects. The number of times the area was recorded is expressed as a percentage of the total answers

Areas of Biology	Grade 7 (Percent of total)	Grade 10-11 (Percent of total)
Ecology and Pollution	33	46
Embryology	18	-
Physiology	12	-
Taxonomy	4	8
Comparative Anatomy	-	15
Heredity	-	-
Plant Growth	-	8
General	33	23

Table 22. Camrose teachers' choices of areas requiring additional resource oriented projects. Totals weighted: three for the first choice, two for the second and one for the third choice

	Grade 7				Grade 10-11				
	Rank			Weighted	Rank			Weighted	
	1	2	3	Total	1	2	3	Total	Sum Total
Ecology	11	1	-	35	7	2	3	28	63
Embryology	1	4	3	14	-	-	-	-	14
Behavior	-	3	2	8	1	-	2	5	13
Taxonomy*	1	2	1	6	1	1	1	6	12
Genetics	-	1	3	5	-	2	1	5	10
Evolution	-	1	1	3	-	2	1	5	8
Physiology	-	-	1	1	-	1	1	3	4
Other	-	-	-	-	-	-	-	2	2

Table 23. Camrose teachers' preferences for individual, small group, or entire class projects. Totals weighted: three for the first choice, two for the second and one for the third choice

	Grade 7				Grade 10-11				
	1	2	3	Total	1	2	3	Total	Sum Total
Individual student projects	3	8	2	27	5	3	1	22	49
Small group projects	9	4	0	35	5	3	1	22	57
Entire class projects	2	1	9	17	1	2	6	13	30

Table 24. Camrose teachers' opinions regarding the percentage of a project which should be conducted in class time

Percentage of Course Time	Percentage of Total (Grade 7 Teachers)	Percentage of Total (Grade 10-11 Teachers)
0 - 10	-	-
10 - 20	-	14
20 - 30	-	-
30 - 40	-	-
40 - 50	20	-
50 - 60	10	14
60 - 70	30	28
70 - 80	20	28
80 - 90	20	14
90 - 100	-	-

Table 25. Camrose teachers' opinions regarding the percentage of biology course time which should be devoted to ecology projects

Percentage of Course Time	Percentage of Total (Grade 7 Teachers)	Percentage of Total (Grade 10-11 Teachers)
0 - 10	0	26
10 - 20	31	12
20 - 30	54	38
30 - 40	15	12
40 - 50	0	12

Table 26. The time of year when ecology projects would be of most help to the Camrose teachers interviewed. Weighted totals are based on three for the first choice, two for the second and one for the third choice. Teachers were allowed to choose equal rank

	Grade 7				Grade 10-11				
	1	2	3	Total	1	2	3	Total	Sum Total
Fall	11	2	0	37	4	5	0	22	59
Winter	1	1	9	14	1	0	7	10	24
Spring	8	5	0	34	8	1	0	26	60

Table 27. Main textbook resource material used by the Camrose teachers

Textbook resource material	The number of times listed by grade 7 teachers expressed as a percentage
Exploring Life Science	47
Science Activities	14
Modern Biology	12
Nuffield Biology	12
Other (Encyclopedias, pamphlets, etc.)	27
	The number of times listed by grade 10-11 teachers expressed as a percentage
BSCS Green Version	38
Modern Biology	31
Other (Pamphlets, old texts, etc.)	31

Table 28. The type of projects found to be most successful and stated to be most desired by the Camrose teachers. S-D indicates teachers did not distinguish between successful and desired, S - most successful, D - most desired.

Type of Projects	Grade 7				Grade 10 - 11			
	S-D	S	D	No. of Times	S-D	S	D	No. of Times
Collecting and classifying local animals and plants	x			4	x			2
Ecology	x			2	x			2
Behavior	x			2				
Pollution	x			1	x			2
Conservation	x			1	x			1
Grasshoppers	x			1				
Cockroaches	x			1				
Terrarium		x		1				
Pond study		x		1				
Hatching duck eggs		x		1				
Fish pollution - acquarium		x		1				
Raising chicks		x		2				
Wormery		x		1				
Frog embryos		x		1				
Definite and obvious conclusion experiments			x	1				
Any project proposed			x	1				
Freshwater or bushland project			x	1			x	1
As broad a variety as possible within the scope of the average student			x	1			x	1

Table 29. Personal information about the pilot study teachers.

	Grade 7		High School	
	Range	Average	Range	Average
Years of University training	2-5	3.6	4-7	5.0
Years of teaching experience	6-33	15.0	2-21	10.9
Number of University courses in biology zoology, botany, genetics, etc.	0-5	1.6	0-30	11.0
Number of University curriculum and instruction courses in (i) biology	0-1	0.6	0-2	1.0
(ii) other sciences	0-3	1.0	0-2	0.7
Approximate number of students you are presently teaching biology (life science)	20-80	50.0	15-180	90.8

Table 30. The manner in which the pilot study teachers rated the objectives of biology project teaching. The information is presented as percentage of total teachers

	Most				Least	
Importance:	6	5	4	3	2	1
Knowledge about facts and principles	-	-	6	6	27	60
Ability to manipulate tools and apparatus	-	6	47	13	6	27
Ability to integrate facts and principles	6	6	33	33	13	6
Understanding of facts and principles	6	6	6	27	47	6
Ability to utilize methods and attitudes to inperpret scientific problems	67	33	-	-	-	-
Ability to apply knowledge to specific situations	20	47	6	20	6	-

Table 31. The average rating on question #4 of pilot study evaluation questionnaire #1 (Appendix C) and evaluation questionnaire #2 (Appendix D) as determined for the total pilot study group. 1 - poor; 2 - fair; 3 - good; 4 - very good; 5 - excellent.

	Questionnaire #1	Questionnaire #2	Significance
All questions	2.9	2.9	1% level
Cognitive questions only	2.7	2.9	n.s.d. at 5%
Affective questions only	2.8	3.0	5% level

Table 32. The average rating on question #4 of pilot study evaluation questionnaire #1 (Appendix C) and evaluation questionnaire #2 (Appendix D) as determined for the high school teachers only.

	Questionnaire #1	Questionnaire #2	Significance
All questions	2.7	3.0	1% level
Cognitive questions only	2.7	2.9	1% level
Affective questions only	1.8	3.2	1% level

Table 33. The average rating on question #4 of pilot study questionnaire #1 (Appendix C) and evaluation questionnaire #2 (Appendix D) as determined for the grade seven teachers only.

	Questionnaire #1	Questionnaire #2	Significance
All questions	3.1	2.9	1% level
Cognitive questions only	3.0	2.9	n.s.d. at 5%
Affective questions only	3.2	3.0	5% level

Table 34. The pilot study teachers rating of the project booklet(s) as a teaching aid. 1 - poor; 2 - fair; 3 - good; 4 - very good; 5 - excellent

	Grade 7	High School	Average
Both students' and teachers' booklets			
Total design	3.0	3.4	3.2
As a source of ideas	4.2	4.0	4.0
As a model for projects	3.8	3.3	3.5
As a unit by itself	2.8	2.4	2.5
As helping to fulfill a project need	3.6	3.5	3.5
Students' booklet only			
Total design	3.0	3.6	3.4
Table of contents	3.2	3.6	3.5
Collecting methods	3.2	3.4	3.3
Culturing methods	3.2	3.2	3.2
Statement of the problem	3.4	3.7	3.6
Suggested designs	3.0	3.3	3.2
Questions	3.5	3.4	3.4
Appendix	3.3	3.5	3.4
Teachers' booklet only			
Total design	3.2	3.3	3.3
Introduction	3.6	3.7	3.6
Information presented	3.4	3.6	3.4
Appendix A	3.3	3.3	3.3
Appendix B	3.4	3.3	3.4

Table 35. The average ratings given by the summer school teachers based on their experience with the writer's projects. 1 - poor; 2 - fair; 3 - good; 4 - very good; 5 - excellent.

	Rating
Project Proposal or Project Outline	
a.) Suitability (Originality, Creativity)	4.3
b.) Clarity of Problem Statement	4.0
c.) Planned use of scientific methodology (controls, replicates, duplicates, etc.)	3.1
d.) Rating on continuum from exercise (probability of a predictable conclusion) to problem, (open-ended answers), to project (a series of related problems).	4.4
The learning resulting from the project	
a.) Knowledge	3.9
b.) Comprehension	3.9
c.) Application	3.8
d.) Analysis	3.5
e.) Synthesis	3.1
f.) Evaluation	3.4

Table 36. The suitability and applicability of the writer's projects to the average Alberta secondary school as rated by the summer school teachers. 1 - poor; 2 - fair; 3 - good; 4 - very good; 5 - excellent

Suitability as a		
a.) Total class project	(average rating)	2.6
b.) Small group project	(average rating)	4.3
c.) Individual (pair) project	(average rating)	4.7

Applicability to the average Alberta secondary school	1 week	2 weeks	1 month	2 months	N/A
a.) Length for total class	14%	57%	-	-	29%
b.) Length for small group		86%	14%	-	-
c.) Length for individual student	-	43%	4%	14%	-
d.) Season best conducted	all year	spring/ fall	spring	fall	winter
	4%	43%	14%	-	-
e.) Equipment needed	easily available		difficult to obtain	not available	
	86%		14%		
f.) Techniques needed	applicable		not applicable		
	86%		14%		
g.) Literature resources needed	available	difficult to obtain		not available	
	71%	29%		-	

Table 37. The 1973 students' evaluation of the writer's projects. The results are expressed in percentage of total students.

Grades:	10	11	12	All grades
Interest level				
a) Very interesting	32	38	44	38
b) Fairly interesting	64	54	56	58
c) Not interesting	4	8	0	4
Difficulty level				
a) Very difficult	8	5	2	5
b) Fairly difficult	50	35	56	47
c) Not difficult	42	60	42	48
Instructions				
a) Very adequate	37	57	43	46
b) Fairly adequate	54	36	46	45
c) Not adequate	9	7	11	9

Table 38. The 1973 students' evaluation of how effective the writer's projects were in helping them to understand the four areas listed. The results are expressed in percentage of total students.

Grade:	10	11	12	All grades
Ecological relationships				
Excellent	5	14	19	11
Very good	30	31	31	30
Good	55	35	42	36
Fair	23	13	5	17
Poor	7	7	3	6
The problem of pollution				
Excellent	11	25	6	17
Very good	27	22	25	24
Good	37	25	13	30
Fair	14	13	28	15
Poor	11	15	28	14
The nature of scientific experiments				
Excellent	6	10	11	8
Very good	26	37	27	30
Good	38	37	43	39
Fair	27	12	16	20
Poor	3	4	3	3
The diversity and identification of local animals				
Excellent	12	21	8	17
Very good	32	23	20	26
Good	27	29	25	28
Fair	16	15	22	16
Poor	13	12	25	13

Table 39. Personal information regarding the 1973 teachers. The average for the 35 teachers who completed all of the evaluation questionnaire #2 and the 19 who completed part of the evaluation questionnaire #2.

	Average (35)	Average (19)
Years of university training	4.9	5.0
Years of teaching experience	5.5	6.1
Years of biology teaching experience	4.6	4.5
University courses in biology	8.0	8.4
University curriculum courses in biology	1.1	1.0
University curriculum courses in other sciences	0.83	0.56
Number of biology students	90	98

Table 40. Significance of differences between the mean rating of answers as recorded in the pre- and post-use teacher questionnaires i.e. question #1 - pilot study evaluation questionnaire #1 vs. question #4 - pilot study evaluation questionnaire #2; question #2 - 1973 evaluation questionnaire #1 vs. question #3 - 1973 evaluation questionnaire #2. $P \leq 0.05$ significant difference, $P \leq 0.01$ highly significant difference;- $P > 0.05$ therefore no significant difference.

Cognitive Domain	Pilot Study	1973 teachers	All teachers
Knowledge			
1. Learn common terms in biology	-	-	-
2. Learn specific facts in biology	-	-	-
3. Learn methods and procedures often used in biology	-	≤ 0.01	≤ 0.01
4. Learn basic concepts in biology	-	-	-
5. Learn principles of biology	-	-	-
6. Recognize local animals	≤ 0.05	≤ 0.05	≤ 0.01
Comprehension			
7. Understand facts and principles in biology	-	≤ 0.01	≤ 0.01
8. Interpret verbal biological material	-	-	-
9. Interpret charts and graphs related to biology	-	-	-
10. Estimate future consequences implied in the gathered data	-	≤ 0.01	≤ 0.01
11. Justify methods and procedures used in biology	-	≤ 0.01	≤ 0.05

Cognitive Domain	Pilot Study	1973 teachers	All teachers
Application			
12. Apply concepts and principles of biology to new situations	≤ 0.05	≤ 0.01	≤ 0.01
13. Apply laws and theories of biology to practical situations	-	≤ 0.01	≤ 0.01
14. Construct charts and graphs from gathered data	-	-	-
15. Demonstrate to classmates and to the teacher correct use of a method or a procedure in biology	-	≤ 0.01	≤ 0.01
16. Collect animals in a systematic and scientific manner	-	≤ 0.01	≤ 0.01
17. Successfully culture animals	≤ 0.05	≤ 0.01	≤ 0.01
Analysis			
18. Recognize unstated assumptions in biological data	-	≤ 0.01	≤ 0.01
19. Recognize logical fallacies in reasoning	-	≤ 0.01	≤ 0.01
20. Distinguish between facts and inferences	-	-	-
21. Evaluate the relevance of biological data	-	≤ 0.01	≤ 0.01
22. Recognize a possible project problem when viewing biological data	-	≤ 0.01	≤ 0.01
Synthesis			
23. Propose a plan for an experiment	-	≤ 0.01	≤ 0.01

Cognitive Domain	Pilot Study	1973 teachers	All teachers
24. Integrate learning from different areas of biology into a plan for solving a problem	-	≤0.01	≤0.01
25. Formulate a project problem from unorganized biological data	-	≤0.01	≤0.01
26. Design an experiment to solve a problem in biology	-	≤0.05	≤0.05
Evaluation			
27. Judge the adequacy with which conclusions are supported by data	-	≤0.05	≤0.05

Affective Domain	Pilot Study	1973 teachers	All teachers
Receiving			
28. Show sensitivity to human needs and social problems related to ecologically oriented biology	-	-	-
29. Attend closely to classroom activities when projects are being conducted or discussed	≤0.05	-	-
Responding			
30. Participate in class discussion when projects were being discussed	≤0.05	-	-
31. Volunteer for special tasks	≤0.01	-	≤0.01
32. Show interest in biology especially ecology	≤0.01	≤0.01	≤0.01

Affective Domain	Pilot Study	1973 teachers	All teachers
33. Treat animals with respect	-	-	-
Valuing			
34. Appreciate the role of biology-ecology in everyday life	-	≤ 0.05	≤ 0.05
35. Demonstrate a problem solving attitude	-	≤ 0.01	≤ 0.01
36. Demonstrate commitment to social improvement	-	-	-
37. Appreciate the role of local animals	≤ 0.01	≤ 0.01	≤ 0.01
38. Appreciate the relevance of ecology to everyday life	-	-	≤ 0.05
39. Appreciate the connection between ecology and pollution	-	-	-
40. Appreciate the biological basis of pollution	-	-	-
41. Demonstrate the social implications of changing the environment	-	-	-
Organization			
42. Recognize the role of systematic planning in solving problems related to biology-ecology	≤ 0.01	≤ 0.01	≤ 0.01
43. Accept responsibility for their own behavior	≤ 0.05	≤ 0.05	≤ 0.01
44. Understand and accept their own limitations and strengths	≤ 0.05	-	-

Affective Domain	Pilot Study	1973 teachers	All teachers
45. Recognize further biological problems arising from the results of a completed project	≤0.01	≤0.05	≤0.01
Characterization by a Value or Value Complex			
46. Demonstrate self-reliance in working independently	≤0.01	-	≤0.01
47. Practice cooperation in group activities	-	-	-
48. Use an objective approach in problem solving	≤0.01	≤0.01	≤0.01
49. Demonstrate industry, punctuality and self-discipline while conducting the project	-	≤0.01	≤0.01
50. Work independently on a subject of their own interest	≤0.05	≤0.01	≤0.01

Table 41. The 1973 and total teachers' ratings of the books as a teaching aid. Legend: P.S. means pilot study; 1973+ means the 1973 teachers who answered the 50 questions; 1973- means the 1973 teachers who did not answer the 50 questions; 1973 means all 1973 teachers; total means all teachers. 1 - poor; 2 - fair; 3 - good; 4 - very good; 5 - excellent.

	P.S.	1973+	1973-	1973	Total
Both students' and teachers' manuals					
Total design	3.4	3.6	2.9	3.5	3.4
As a source of ideas	4.0	4.1	3.6	4.0	4.0
As a model for projects	3.3	3.3	3.4	3.3	3.3
As a unit by itself	2.4	2.7	2.5	2.7	2.7
As helping to fulfill a project need	3.5	3.7	3.5	3.6	3.6
Students' manual only					
Total design	3.6	3.6	2.8	3.4	3.5
Table of contents	3.6	3.4	2.7	3.2	3.3
Collecting methods	3.4	3.9	3.5	3.8	3.8
Culturing methods	3.2	3.8	3.5	3.8	3.7
Statement of problem	3.7	3.6	3.5	3.6	3.6
Suggested designs	3.3	3.6	3.5	3.6	3.6
Questions	3.4	3.6	3.5	3.8	3.7
Appendix	3.5	3.9	3.3	3.5	3.5
Teachers' manual only					
Total design	3.3	3.6	3.5	3.5	3.5
Introduction	3.7	3.3	3.4	3.3	3.4
Information presented	3.6	3.8	3.7	3.8	3.8
Appendix A	3.3	3.7	3.9	3.8	3.7
Appendix B	3.3	3.5	3.5	3.5	3.5

APPENDICES

APPENDIX A

CAMROSE TEACHERS INTERVIEW FORM

No. ______

Date __________________ School __________________________ Grade ________

1. In what areas of biology are your students currently conducting, or have recently conducted projects?

2. Would you like additional resource oriented projects to assist you in teaching biology?

YES __________

NO __________

3. If yes, in which area of biology would these be most helpful? (Please select three and rank in order of choice)

Ecology, Embryology, Evolution, Genetics, Taxonomy, Behavior, Physiology, Other ________________.

4. Which of the following would you prefer? (Please rank - 1, 2, 3)

   a) individual student projects? (The student would conduct the project requiring a minimum of teacher supervision) __________

   b) Small group student projects? (The student would conduct the project requiring a minimum of teacher supervision) __________

   c) Entire class projects? __________

5. In your opinion, when should the major portion of the project be conducted:

   a) In class time? or __________

   b) Out of class time? __________

6. If the projects were restricted to the field of ecology, approximately what percentage of the total biology class time should be devoted to these projects? (Please check one)

0 - 10% ________
10 - 20% ________
20 - 30% ________
Over 30% ________ If so, approximately what percent?

____

7. If the projects were restricted to the field of ecology, during what time of the year would the projects be most helpful? Please rank 1, 2, 3, or if equal worth, 1, 1, 1, or any other combination.

a) fall ____________ b) winter ______________ c) spring ______

8. Which text books provided you with your main resource material during the current year?

9. From your experience, do you have any suggestions regarding the type of projects which you have found successful or which you think you would like?

APPENDIX B

CAMROSE TEACHERS PERSONAL INFORMATION QUESTIONNAIRE

Personal information questionnaire completed by all teachers in the study.

1. How many years have you been teaching? ______________

2. How many of these years did you teach

   a) a biology course and/or

   b) a related course

   Example: Agriculture, Life Science, Nature Study etc. ______________

3. Approximately what percent of your professional duties in the school year 1970-71 were connected with the teaching of biology or related courses ______________

4. What was your major field of training?

   Biology_______ Physical Education _______ History _______ Other ______

5. Degrees held if any ______________

6. How many years of post high school training have you acquired? ________

7. Please list the biology or related courses which you have studied in your post high school training

COURSE NAME	FULL YEAR	HALF YEAR	INSTITUTE	YEAR STUDIED
e.g. Genetics	X		Camrose	1967

APPENDIX C

PILOT STUDY EVALUATION QUESTIONNAIRE #1

1. Teacher information: (a) Years of University training? ________
(b) Years of teaching experience? ________
(c) Number of university courses in biology, zoology, botany, genetics, etc. ________
(d) Number of university curriculum and instruction courses in (i) biology? ________
(ii) other sciences? ________
(e) Approximate number of students you are presently teaching biology (life science) to: ________

2. The following six objectives of biology were listed by a group of teachers. Please rank these starting with what you consider to be the most important down to what you consider the least important.

Example: Most important: 5, 1, 2, 3, 6, 4 Least important.
Most important: ____________ Least important.

1.) Knowledge about facts and principles.
2.) Ability to manipulate tools and apparatus.
3.) Ability to integrate facts and principles.
4.) Understanding of facts and principles.
5.) Ability to utilize methods and attitudes to interpret scientific problems.
6.) Ability to apply knowledge to specific situations.

3. Please rank the same six objectives this time thinking of them as objectives for biology project teaching only.

Most important: ____________ Least important.

4. In your opinion how effective have the ECOLOGY ORIENTED BIOLOGY PROJECTS completed by your students in the last two (2) years been in motivating students to: (Please check one of the ratings.)

Numerical rating	1	2	3	4	5
Verbal rating	poor	fair	good	v.good	excellent

1. Interpret charts and graphs related to biology.
2. Recognize logical fallacies in reasoning.
3. Interpret verbal biological material.
4. Demonstrate industry, punctuality and self discipline while conducting the project.

Numeral ratings:	1	2	3	4	5
Verbal ratings;	poor	fair	good	v. good	excellent

5. Justify methods and procedures used in biology.
6. Integrate learning from different areas of biology into a plan for solving a problem.
7. Estimate future consequences implied in the gathered data.
8. Understand facts and principles in biology.
9. Appreciate the connection between ecology and pollution.
10. Propose a plan for an experiment.
11. Volunteer for special tasks.
12. Recognize a possible project problem when viewing biological data.
13. Attend closely to classroom activities when projects were being conducted or discussed.
14. Recognize further problems* arising from the results of a completed project.
*biological.
15. Formulate a project problem from unorganized biological data.
16. Work independently on a subject of their own interest.
17. Apply laws and theories of biology to practical situations.
18. Show sensitivity to human needs and social problems related to ecological oriented biology.
19. Collect animals in a systematic and scientific manner.
20. Accept responsibility for their own behavior.
21. Demonstrate a problem-solving attitude.
22. Recognize local animals.
23. Participate in class discussion when projects were being discussed.

Numeral rating:	1	2	3	4	5
Verbal rating:	poor	fair	good	v. good	excellent

24. Appreciate the relevance of ecology to everyday life.
25. Learn basic concepts in biology.
26. Use an objective approach in problem solving.
27. Demonstrate commitment to social improvement.
28. Demonstrate self-reliance in working independently.
29. Learn common terms in biology.
30. Successfully culture animals.
31. Appreciate the role of local animals in everyday life.
32. Learn specific facts in biology.
33. Treat animals with respect.
34. Practice cooperation in group activities.
35. Apply concepts and principles of biology to new situations.
36. Evaluate the relevance of biological data.
37. Show interest in biology especially ecology.
38. Understand and accept their own limitations and strengths.
39. Learn principles of biology.
40. Construct charts and graphs from gathered data.
41. Appreciate the role of biology-ecology in everyday life.
42. Judge the adequacy with which conclusions are supported by data.
43. Recognize the role of systematic planning in solving problems related to biology-ecology.
44. Recognize unstated assumptions in biological data.

Numeral rating:	1	2	3	4	5
Verbal rating:	poor	fair	good	v. good	excellent
45. Design an experiment to solve a problem in biology.					
46. Learn methods and procedures often used in biology.					
47. Appreciate the biological basis of pollution.					
48. Distinguish between facts and inferences.					
49. Demonstrate the social implications of changing the environment.					
50. Demonstrate to classmates and to the teacher correct use of a method or a procedure in biology.					

APPENDIX D

PILOT STUDY EVALUATION QUESTIONNAIRE #2

Name ____________________________ School ______________________________

The number of students that used the book(s) either directly or through you ____________. The grade level of these students ________________.

1. Please check the parts used by these students. If you used a part please mark this with an X.

	Protozoa	Hydra	Earthworm	Snail	House fly	Mosquito	Pheasants Grouse	Ground Squirrel
Collecting Methods								
Culturing Methods								
Problem 1, 2, etc. (Indicate which)								
Students' Appendix								
Teachers' Information								
Teachers' Appendix A.								
Teachers' Appendix B.								

2. Based on students' experience as checked in question one and on your evaluation please rate the effectiveness of the book(s) as a teaching aid.

Numeral Rating:	1	2	3	4	5
Verbal Rating:	poor	fair	good	v. good	excellent

Both students' and teachers' manuals:

Total design

As a source of ideas

As a model for projects

As a unit by itself

As helping to fulfill a project need

Numeral Rating:	1	2	3	4	5
Verbal Rating:	poor	fair	good	v. good	excellent

Students' Manual only:

Total design

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Statement of the problem

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Teachers' Manual Only:

Total design

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3. Any comments regarding the book(s)? Use the reverse side if necessary.

4. In your opinion how effective were the projects in motivating students to: (Please check one of the ratings).

Numeral rating:	1	2	3	4	5
Verbal rating:	poor	fair	good	v. good	excellent

1. Understand facts and principles in biology.
2. Demonstrate a problem solving attitude.
3. Appreciate the biological basis of pollution.
4. Work independently on a subject of their own interest.
5. Demonstrate the social implications of changing the environment.
6. Apply laws and theories of biology to practical situations.
7. Appreciate the role of local animals in everyday life.
8. Apply concepts and principles of biology to new situations.
9. Recognize further biological problems arising from the results of a completed project.
10. Accept responsibility for their own behavior.
11. Collect animals in a systematic and scientific manner.
12. Distinquish between facts and inferences.
13. Recognize a possible project problem when viewing biological data.
14. Propose a plan for an experiment.
15. Learn basic concepts in biology.
16. Learn principles of biology.
17. Show sensitivity to human needs and social problems related to ecological oriented biology.
18. Learn methods and procedures often used in biology.
19. Practice cooperation in group activities.
20. Appreciate the relevance of ecology to everyday life.
21. Learn common terms in biology.
22. Construct charts and graphs from gathered data.
23. Appreciate the connection between ecology and pollution.

	Numeral rating:	1	2	3	4	5
	Verbal rating:	poor	fair	good	v. good	excellent
24.	Attend closely to classroom activities when projects ~~were being~~ conducted or discussed.					
25.	Demonstrate self-reliance in working independently.					
26.	Recognize local animals.					
27.	Recognize unstated assumptions in biological data.					
28.	Understand and accept their own limitations and strengths					
29.	Demonstrate industry, punctuality and self-discipline while conducting the project.					
30.	Successfully culture animals					
31.	Volunteer for special tasks.					
32.	Formulate a project problem from unorganized biological data.					
33.	Participate in class discussion when projects were being discussed.					
34.	Treat animals with respect.					
35.	Show interest in biology especially ecology.					
36.	Recognize logical fallacies in reasoning.					
37.	Demonstrate commitment to social improvement.					
38.	Appreciate the role of biology-ecology in everyday life.					
39.	Interpret verbal biological material.					
40.	Judge the adequacy with which conclusions are supported by data.					
41.	Interpret charts and graphs related to biology.					
42.	Use an objective approach in problem solving.					
43.	Evaluate the relevance of biological data.					
44.	Learn specific facts in biology.					

Numeral rating:	1	2	3	4	5
Verbal rating:	poor	fair	good	v. good	excellent

45. Design an experiment to solve a problem in biology.
46. Recognize the role of systematic planning in solving problems related to biology-ecology.
47. Estimate future consequences implied in the gathered data.
48. Integrate learning from different areas of biology into a plan for solving a problem.
49. Justify methods and procedures used in biology.
50. Demonstrate to classmates and to the teacher correct use of a method or a procedure in biology.

APPENDIX E

SUMMER SCHOOL EVALUATION QUESTIONNAIRE #3

PROJECT TITLE ________________________________

PARTICIPANT(S) NAME(S) ________________________

EVALUATOR'S NAME _____________________________

Verbal rating:	Poor	Fair	Good	V. Good	Excellent
Numeral rating:	1	2	3	4	5

1. Project Proposal or Project Outline Suitability (Originality, Creativity)

   Clarity of problem statement

   Planned use of scientific methodology (controls, replicates, duplicates, etc.)

   Rating on continuum from exercise, (probability of a predictable conclusion) to problem, (open-ended answers) to project (a series of related problems)

2. The manner in which the project was handled.

   a) Preparation
   Literature research and/or project proposal

   b) Conducting the project
   Scientific methodology employed (controls, etc.)
   Resourcefulness employed

   c) Reporting of the project (written; oral; demonstration material, model, audio visual, examples etc.)

3. The learning resulting from the project

   a) knowledge
   b) comprehension
   c) application
   d) analysis
   e) synthesis
   f) evaluation

Verbal rating:	Poor	Fair	Good	V. Good	Excellent
Numeral rating:	1	2	3	4	5

4. Suitability of project to the average Alberta secondary school as a

   a) Total class project
   b) Small group project
   c) Individual (pair) project

   Applicability to the average Alberta secondary school

   a) Length - total class ______________
   small group ______________
   individual ______________

   b) Season - spring ________________
   winter ________________
   fall ________________

   c) Equipment needed
   easily available ________
   difficult to obtain ______
   not available ________

   d) Techniques needed
   applicable ____________
   not applicable ________

   e) Literature resources needed
   available ____________
   difficult to obtain ______
   not available ________

APPENDIX F

GENERAL OBJECTIVES OF HIGH SCHOOL BIOLOGY COURSES

1. To enable the student to familiarize himself with his immediate biological world and to realize the importance of the interdependence of living organisms, and the part man plays in this scheme.

2. To develop the ability of a student to carry out successful independent study and learning.

3. To develop sound procedures for biological field and indoor laboratory study.

4. To develop an understanding of and an appreciation for the methods used by scientists; the means and conditions under which science advances; the role of biologists; the importance of accurate and accessible records, constantly improved instruments, and free communication.

APPENDIX G

1973 TEACHER'S QUESTIONNAIRE NO. 1

1. Teacher Information:
   - (a) Name ____________________
   - (b) School ____________________
   - (c) Address ____________________
   - (d) Years of University training? __________
   - (e) Years of teaching experience? __________
   - (f) Years of biology teaching experience? ____
   - (g) Number of University courses in biology, zoology, botany, genetics, etc.? __________
   - (h) Number of University curriculum and instruction courses in:
     - (i) biology? ____________________
     - (ii) other sciences? ____________________
   - (i) Approximate number of students you are presently teaching biology (life science) to? ____________________

2. In your opinion how effective have the ECOLOGY ORIENTED BIOLOGY PROJECTS completed by your students been in motivating students to: (Please check one of the ratings).

Numeral rating: Verbal rating:	1 poor	2 fair	3 good	4 v. good	5 excel-lent
1. Interpret charts and graphs related to biology.					
2. Recognize logical fallacies in reasoning.					
3. Interpret verbal biological material.					
4. Demonstrate industry, punctuality and self discipline while conducting the project.					
5. Justify methods and procedures used in biology.					
6. Integrate learning from different areas of biology into a plan for solving a problem.					
7. Estimate future consequences implied in the gathered data.					
8. Understand facts and principles in biology.					
9. Appreciate the connection between ecology and pollution.					

Numeral rating:	1	2	3	4	5
Verbal rating:	poor	fair	good	v. good	excellent
10. Propose a plan for an experiment.					
11. Volunteer for special tasks.					
12. Recognize a possible project problem when viewing biological data.					
13. Attend closely to classroom activities when projects were being conducted or discussed.					
14. Recognize further biological problems arising from the results of a completed project.					
15. Formulate a project problem from unorganized biological data.					
16. Work independently on a subject of their own interest.					
17. Apply laws and theories of biology to practical situations.					
18. Show sensitivity to human needs and social problems related to ecological oriented biology.					
19. Collect animals in a systematic and scientific manner.					
20. Accept responsibility for their own behavior.					
21. Demonstrate a problem-solving attitude.					
22. Recognize local animals.					
23. Participate in class discussion when projects were being discussed.					
24. Appreciate the relevance of ecology to everyday life.					
25. Learn basic concepts in biology.					
26. Use an objective approach in problem solving.					
27. Demonstrate commitment to social improvement.					
28. Demonstrate self-reliance in working independently.					
29. Learn common terms in biology.					
30. Successfully culture animals.					
31. Appreciate the role of local animals in everyday life.					
32. Learn specific facts in biology.					
33. Treat animals with respect.					

Numeral rating: Verbal rating:	1 poor	2 fair	3 good	4 v. good	5 excellent
34. Practice cooperation in group activities.					
35. Apply concepts and principles of biology to new situations.					
36. Evaluate the relevance of biological data.					
37. Show interest in biology especially ecology.					
38. Understand and accept their own limitations and strengths.					
39. Learn principles of biology.					
40. Construct charts and graphs from gathered data.					
41. Appreciate the role of biology-ecology in everyday life.					
42. Judge the adequacy with which conclusions are supported by data.					
43. Recognize the role of systematic planning in solving problems related to biology-ecology.					
44. Recognize unstated assumptions in biological data.					
45. Design an experiment to solve a problem in biology.					
46. Learn methods and procedures often used in biology.					
47. Appreciate the biological basis of pollution.					
48. Distinguish between facts and inferences.					
49. Demonstrate the social implications of changing the environment.					
50. Demonstrate to classmates and to the teacher correct use of a method or a procedure in biology.					

APPENDIX H

1973 TEACHER'S QUESTIONNAIRE NO. 2

Name ______________________________ School ______________________________

1. Based on students' experience and on your evaluation please rate the effectiveness of the book(s) as a teaching aid.

Numeral Rating	1	2	3	4	5
Verbal Rating	Poor	Fair	Good	V. Good	Excellent
Both students' and teachers' manuals:					
Total design					
As a source of ideas					
As a model for projects					
As a unit by itself					
As helping to fulfill a project need					

Numeral Rating	1	2	3	4	5
Verbal Rating	Poor	Fair	Good	V. Good	Excellent
Students' Manual only:					
Total Design					
Table of Contents					
Collecting methods					
Culturing methods					
Statement of the problem					
Suggested designs					
Questions					
Appendix					

Numeral Rating	1	2	3	4	5
Verbal Rating	Poor	Fair	Good	V. Good	Excellent
Teachers' Manual only:					
Total design					
Introduction					
Information presented					
Appendix A					
Appendix B					

2. Any comments regarding the book(s)? Use the reverse side if necessary.

3. In your opinion how effective were the ECOLOGY - POLLUTION PROJECTS in motivating students to: (Please check one of the ratings).

Numeral rating	1	2	3	4	5
Verbal rating	Poor	Fair	Good	V. Good	Excellent
1. Interpret charts and graphs related to biology.					
2. Recognize logical fallacies in reasoning.					

Numeral rating	1	2	3	4	5
Verbal rating	Poor	Fair	Good	V. Good	Excellent
3. Interpret verbal biological material.					
4. Demonstrate industry, punctuality and self discipline while conducting the project.					
5. Justify methods and procedures used in biology.					
6. Intergrate learning from different areas of biology into a plan for solving a problem.					
7. Estimate future consequences implied in the gathered data.					
8. Understand facts and principles in biology.					
9. Appreciate the connection between ecology and pollution.					
10. Propose a plan for an experiment.					
11. Volunteer for special tasks.					
12. Recognize a possible project problem when viewing biological data.					
13. Attend closely to classroom activities when projects were being conducted or discussed.					
14. Recognize further biological problems arising from the results of a completed project.					
15. Formulate a project problem from unorganized biological data.					
16. Work independently on a subject of their own interest.					
17. Apply laws and theories of biology to practical situations.					
18. Show sensitivity to Human needs and social problems related to ecological oriented biology.					
19. Collect animals in a systematic and scientific manner.					
20. Accept responsibility for their own behavior.					
21. Demonstrate a problem-solving attitude.					
22. Recognize local animals.					
23. Participate in class discussion when projects were being discussed.					
24. Appreciate the relevance of ecology to everyday life.					

Numeral rating	1	2	3	4	5
Verbal rating	Poor	Fair	Good	V. Good	Excellent
25. Learn basic concepts in biology.					
26. Use an objective approach in problem solving.					
27. Demonstrate commitment to social improvement.					
28. Demonstrate self-reliance in working independently.					
29. Learn common terms in biology.					
30. Successfully culture animals.					
31. Appreciate the role of local animals in everyday life.					
32. Learn specific facts in biology.					
33. Treat animals with respect.					
34. Practice cooperation in group activities.					
35. Apply concepts and principles of biology to new situations.					
36. Evaluate the relevance of biological data.					
37. Show interest in biology especially ecology.					
38. Understand and accept their own limitations and strengths.					
39. Learn principles of biology.					
40. Construct charts and graphs from gathered data.					
41. Appreciate the role of biology-ecology in everyday life.					
42. Judge the adequacy with which conclusions are supported by data.					
43. Recognize the role of systematic planning in solving problems related to biology-ecology.					
44. Recognize unstated assumptions in biological data.					
45. Design an experiment to solve a problem in biology.					
46. Learn methods and procedures often used in biology.					
47. Appreciate the biological basis of pollution.					
48. Distinguish between facts and inferences.					
49. Demonstrate the social implications of changing the environment.					
50. Demonstrate to classmates and to the teacher correct use of a method or a procedure in biology.					

4. If none of the ECOLOGY - POLLUTION PROJECTS were attempted could you please indicate why.

(a) Time wasn't available ______

(b) Students chose their own projects ______

(c) Projects not applicable this semester ______
If not applicable do you intend to use the projects in the future
Yes ______
No ______

(d) Projects not suitable ______
Please explain

______

______

______

______

______

______

______

APPENDIX I

1973 STUDENT'S QUESTIONNAIRE

Name:

Grade:

School:

1. List the animal used and the problem attempted. Example: Ants - Problem 2.

2. Please check one answer only in each of the following groups.

   (a) Was the project:
   - (a) very interesting? ________
   - (b) fairly interesting? ________
   - (c) not interesting? ________

   (b) Was the project:
   - (a) very difficult? ________
   - (b) fairly difficult? ________
   - (c) not difficult? ________

   (c) Were the instructions:
   - (a) very adequate? ________
   - (b) fairly adequate? ________
   - (c) not adequate? ________

3. How effective was the project in helping you understand:

Numerical Rating	5	4	3	2	1
Verbal Rating	Excellent	V. Good	Good	Fair	Poor
(a) Ecological relationships?					
(b) The problem of pollution?					
(c) The nature of scientific experiments?					
(d) The diversity of and the identification of local animals?					

4. Would you like to do more projects of a similar nature? Yes ______ No ______

   Why or why not? ________________________________

   ____

   ____

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ECOLOGY - PROJECTS

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INTRODUCTION

Ecology has become a popular word. What does it mean? The word is derived from the Greek oikos, meaning "house" or "place to live." Therefore it means the study of organisms "at home." It is a study of the interrelations between living organisms and their environment. If you are to discover these interrelationships, then you must study both the environment and the living organism. While it may be helpful to study the dead animal in the laboratory, the study here must be done with the living animal in its natural environment. This book of projects tries to give you the tools, the methods, so that you might be able to discover, and better understand, the vital interrelationships between an organism and its environment.

A number of the projects suggest capturing animals alive. Since every animal has its role in the ecosystem, it deserves to be treated with respect. The projects suggested try to avoid providing an opportunity for cruelty to animals. The onus to treat every organism in the most humane manner possible, is, however, on you. Therefore, if you have collected and cultured some live organisms and have completed the project, either humanely destroy them or return them to the habitat from which you collected them. Please DO NOT release any live animal or plant of any description into a different habitat from that from which you collected it. The organism might not be able to adapt to the new habitat and so would die. On the other hand, the organism might adapt very well to the new habitat and might multiply rapidly. The introduction of the rabbit into Australia or the house sparrow into North America should provide you with a case study of the latter danger. Have fun, discover, and try to understand.

PROJECTS USING PROTOZOA

GENERAL METHODS

COLLECTING:

Protozoa may be collected from any slough, dugout, pond, stream, etc. Collections from these areas should include water plants, algae, decaying vegetation and some ooze from the bottom as well as surface water. No elaborate equipment is required. For example, one might use a bucket, his hands, a home-made net (Appendix A-8) and quart sealer.

EQUIPMENT:

Plastic bags or quart sealers, garden rake, and rubber boots.

OBSERVING:

A microscope is required to observe these animals properly. Remove a drop or several drops of water from the collected mixture and place on a microscope slide or watch glass and observe.

EQUIPMENT:

Microscope, slides or watch glass, eye dropper, capillary pipette or something comparable.

CULTURING:

a) Short term (about one month). The culture can be maintained with no additional care if kept in the water in which it was collected. Place the collected water and materials in a quart sealer, leave top open and place sealers in moderate but not bright light. Keep the material at room temperature.

b) Long term. Maintain the cultures in any glass containers, e.g. quart sealer. Use a clean container, avoid bright light, and avoid extremes of temperature. Consult your teacher for further details.

SUGGESTED PROJECTS

Select one, any number or all of the following as a project.

PROBLEM 1. What are some factors which determine where Protozoa live?

Suggested Design:

Use one, any number or all of the collecting methods suggested for this project. Be sure to label each collection immediately.

Suggested Collecting Sites:

a) Select one body of water (e.g. slough) and collect from only one location.

b) Select one body of water and collect from 5 to 10 different locations. For example: from a creek, an inlet, the windward side of the water body, the sheltered side of the water body, a shallow area, a deep area, an area with plants, an area without plants, an area with a mud bottom, an area with a sandy bottom or gravel bottom, etc.

c) Select two different bodies of water and collect from a similar location in each body of water. For example, the windward side from both the slough and the creek.

d) Select two different bodies of water and collect from 5 to 10 comparative locations.

Suggested Collecting Methods:

a) Collect one quart of water from each site selected.

b) Collect one quart of water filled ½ full of floating plants or surface plants from each site selected.

c) Collect one quart of water filled ½ full of bottom debris.

d) Collect one quart of water filled ½ full with surface plants and ½ with bottom debris.

Record one or more of the following:

a) The total number of Protozoa found in each quart of water from each site; (Ask your teacher regarding the method of taking subsamples so that you can estimate the total number of Protozoa in the quart container.)

b) The main kinds of Protozoa found in each quart of water from each of these samples. For example, did the culture contain mainly Paramecium or mainly Euglena?

c) The number of Protozoa found in each quart of water from each site, the main kinds, and the relative numbers of the main kinds found. For example, did you find one Paramecium for every one Euglena?

Questions:

Was your sampling from the body of water accurate and representative?

Did you sample at the same depth, at the same time of day, using the same method?

Was your subsampling from your collection accurate and representative?

Was your counting comparative and accurate?

Did you always look at the same number of drops of water?

Did you find the same number of Protozoa in each sample?

Did you find the same kinds of Protozoa in each sample?

Which animal dominated one area, which another?

Which sample had the greatest variety of animals? Can you suggest a reason?

Did the sample from the body of water that had the greatest number of microhabitats have the greatest variety of animals?

Did the sample from the body of water that appeared to be the "dirtiest" have the greatest variety of animals?

What are some reasons for differences, if differences were found?

Do you think physical, (e.g. depth of water, etc.) chemical (e.g. pH, etc.) or biological (e.g. species of plants, etc.) factors control the distribution of Protozoa?

Can you test your answer experimentally? Try to design an experiment with the help of your teacher.

PROBLEM 2. How does light, temperature, oxygen, etc., affect the distribution of Protozoa?

Suggested Design:

Select the body (bodies) of water desired, the collecting method(s) desired, and the recording method(s) desired. While you are collecting the animals you should record, as time or equipment allows, any or all of the following:

	Equipment Needed
1. Temperature of water	thermometer
2. pH of water	pH paper
3. Dissolved oxygen of water	see Appendix A-1
4. Salinity of water	see Appendix A-2
5. Light in the water (color and Turbidity)	see Appendix A-3
6. Time of day, date	

Questions:

Did you find any relationship between one of the above factors and the different kind(s) and/or number(s) of different Protozoa found in each collection? If not, what other factors do you think could be determining the kind and number of Protozoa collected? Could you test these factors in a laboratory or in a field experiment?

PROBLEM 3. How do other animals interact with Protozoa?

Suggested Design:

Select your water(s), collecting method(s) and recording method(s). Collect Protozoa. In addition record the number and kind of all other animals besides Protozoa that you find in your collection. (Ask your teacher about taking subsamples from your collection. Your total collection may contain so many animals that you wouldn't have the time or energy to count and identify all of them.) Observe, or use literature review or experiments to find out whether the other animals are: (1) beneficial to, (2) harmful to, or (3) neutral to the Protozoa collected.

Questions:

Did all of the Protozoans collected eat the same food?
Could you set up a series of experiments offering Protozoan one or several choices of different foods?
Did your culture get smelly as it got older?
Does this happen in the natural environment? Why or why not?
Can you classify the Protozoa collected into producers, consumers, scavengers, or decomposers?

PROBLEM 4. Succession in a mixed Protozoan culture.

Suggested Design:

Collect Protozoa and establish a culture in the laboratory. Take samples from your culture(s) regularly (e.g., every two days) for a period of at least two to four weeks. Take samples from the top (air-water interface), the middle and from the bottom (mud-water interface) of the quart sealer each time. Record the number and the kinds of Protozoa each time you sample your culture.

Questions:

How did you sample your culture? Did you take the same amount of water in each sample? Did you note a change in the number of

Protozoa over a period of time? Was there a corresponding change in the condition of the water? If a change occurred why do you think the change occurred? Might it be due to lack of space, changing or decreasing food supply, change in pH, oxygen, predation? Can you test your answers with more experiments? For example, what happens when you:

a) start one culture in a quart sealer full of water and the other in a 2-quart sealer full of water?

b) double the space available after a certain time (e.g. one week after the experiment was started) by adding distilled or aged tap water?

c) aerate one sealer and leave the other alone?

d) place one sealer sealed with a lid, in a slough and leave another in the laboratory?

Was an experiment using one one-quart sealer enough to provide definite answers? Did you have controls? Can you correlate the change seen in the laboratory with results obtained under natural conditions? See parts one, two and three of this project for ideas about how you may attempt this. Do you think animals determine the environment or does the environment determine which and how many animals are found in a habitat?

PROBLEM 5. Population change in a Paramecium culture.

Suggested Design:

Problem 5 and 6 deal with only two Protozoans, Paramecium and Didinium. See your teacher for help in identifying these Protozoans.

These are best collected from the oozy debris at the bottom of old, permanent ponds. Keep the collection in a bowl with just a small amount of water in it. Remember to place the bowls in moderate but not bright light and in an area which will avoid extremes of temperature. The organisms become more abundant as the debris becomes more foul smelling. Establish a pure Paramecium culture as instructed by your teacher. It may be easier to establish a number of smaller pure cultures in containers such as watch glasses. The whole watch glass can then be placed under a dissecting microscope for easy counting. Start your culture with a set number of Paramecium (e.g. 20 or 100). By counting every 2 or 3 days record the change in numbers over a period of time (2 to 4 weeks) if cultured under:

1. favorable conditions - moderate light, room temperature, neutral pH, no disturbance, etc., and/or
2. if cultured under different conditions. Vary one condition only per experiment. Use duplicate jars plus a control. The variable could be introduced at the beginning of the experiment or it could be introduced at a set time after the beginning of the experiment, e.g. 1 week.

Questions:

How many cultures are needed to get reliable results? Do you need only one culture for each new set of conditions? Why or why not? How many times were the experiments repeated? Did you have a control? What happens to the population if you double the space or the food? What happens if you fertilize the culture by adding a set amount of commercial fertilizer per day, or what happens if you pollute the culture? Is there a reduction or increase in total numbers? Ask your teacher to help you construct a graph of the change of numbers of individuals in the population(s). You may wish to use this graph to plot a growth curve and to compare this growth curve with that of other animals. Do the numbers of Paramecium in a pure Paramecium culture change differently than the numbers of Paramecium in a mixed Protozoan culture if both are subjected to the same conditions? Test this. Does an old mixed Protozoan culture have more or fewer kinds of animals than a young mixed Protozoan culture?

PROBLEM 6. Is a system containing a predator and a prey always in balance?

Suggested Design:

Set up a culture that contains a set ratio of Paramecium to Didinium; for example, half to half or 50 Paramecium to 50 Didinium. Place the culture under any or all of the different conditions suggested in problem 5 of this project and record the number of animals at daily intervals. Remember the controls and the replicates.

Questions:

Did the Didinium eat all of the Paramecium or was a balance established? If a balance was established did the populations always level at the same ratio or at the same number or at both? What do you think controls the population numbers of these animals in the pond? Have you evidence for your answer? Is predation always harmful? Is it ever harmful? When?

WINTER CONSIDERATIONS

Problems 1, 3, 4 and possibly 5 and 6 could be conducted in winter. The success of problems 3, 4, 5 and 6 would depend on the collecting success achieved by following the design suggested in problem 1. The design should be modified to include at least one sample of bottom mud collected from the edge of the body of water under study. The mud collected should contain some vegetable matter. One method of collecting this mud would be to chop a hole in the ice in an area where you would anticipate finding 1 or 2 inches of water. The hole could be chopped with an axe or with an ice pick. Some mud could then be collected in an extra plastic bag. The mud could then be taken to the laboratory and a measured amount removed and weighed for the experiment. Weighing the mud samples would be one way to insure that results obtained from different samples were comparable. A measured amount of water, i.e. "natural, distilled or aged tap water", should then be added to the samples and the results recorded as outlined in the problems.

PROJECTS USING HYDRAS

6

GENERAL METHODS

COLLECTING:

A beginner may have difficulty in finding and seeing hydras in their natural habitat. Most of the time they can be located on the undersurface of underwater plants. However, hydras have a habit of contracting when disturbed. Therefore use either one of the following techniques:

1. Dump clean water and plants in a white-bottomed tray such as an enamel pan, a refrigerator tray or a large agate-coated photographic tray. Wait 10 minutes and then examine plant surfaces. Any hydras should stand out against the white (tray) background.
2. Fill a plastic bag half full of the water from which you are trying to collect hydras. Place a few underwater plants in the bucket or in the plastic bag. Leave undisturbed for about ten minutes. Again any hydras should be seen on the plants or on the inner surface of the bag.
3. Fill a plastic bucket or a plastic bag half full of the water from which you are trying to collect hydras. Place some underwater plants (quarter full) in the container chosen. Return to the laboratory or your home. Leave undisturbed overnight. Examine the next day without disturbing. The hydras should be searching for oxygen near the surface of the water or else be attached to the

inner surface of the containers used.

EQUIPMENT:

Rubber boots or hip waders, plastic bags or other containers, long handled rake for collecting plants, eye droppers for removing the hydras.

OBSERVING:

Hydras are large enough so that they can be seen without the aid of a microscope. A hand lens or a binocular microscope is useful, however.

CULTURING:

a) Short term (about two weeks) depending on temperature. Keep hydras in a glass container (e.g. quart or pint sealer). Use only the water in which they were collected, add a few plants and place in moderate but not direct light. Feed other pond animals such as Daphnia.

b) Long term. Place the animals in a mini-aquarium (Appendix A-4).

SUGGESTED PROJECTS

Select one, any number or all of the following as a project.

PROBLEM 1. To find some factors which determine where hydras can be found.

Suggested Design:

Collect hydras from:

a) One body of water only (e.g. a slough). Record the kind of plant from which they were collected. For example, did you collect some from cattails, some from "grasses"?

b) Collect from two or more bodies of water (e.g. creek, slough, dugout, etc.). In each body of water examine and keep separate as many different plant species as you can find. Try to collect the same kinds of plants in different water bodies.

Questions:

Did you find hydras on only one type of plant? Did you find hydras in only one type of aquatic habitat? If so, did you find hydras on the same plant in a number of different habitats (environment)? If so, did you find the same number of hydras on this plant regardless of the water body sampled? If you did not get any consistent results why might this be? Did you collect the same amount of water from each habitat? Did you collect only one sample from each collection site? Did you examine the same number of water plants from each site? Was your collecting method standard? What do you think could be limiting the spread of these animals? Could it be temperature, oxygen? Could it be food or predators? Determine the reason through literature research, more field studies and laboratory studies. For example, have you tested to see if the hydras collected can live in water from a waterbody in which you failed to find them?

PROBLEM 2. More questions requiring experimental answers.

What do hydras normally eat? What other animals did you find in the water with hydras? What eats hydras? How do hydras in their natural habitat react if the water body dries up? How do these animals react if the water gets old? Where do they go in winter? How do hydras move? How do hydras get from one body of water to another body of water? How do they reproduce their own kind? How do they digest their food? How do they catch their food? What species of hydras did you catch? What color were they? If they were collected with sex organs on them did they carry male, female or both sex organs? Good answers can come only from good observations and accurate experiments. Literature research might be required to answer some of these questions.

PROBLEM 3. To test various pollutants using hydras as a test animal.

Use a population of these animals to test the effect of different pollutants on life in water. Try to test pollutants which may actually be affecting the water in your area. One method may be to place 10 hydras in each of 5 different containers - pint jars or smaller uniform size glass containers are adequate. Keep one container as a control. Why? Add to the other four containers substances such as:

a) four concentrations of oil - one drop, two drops, etc.
b) four different oils using the same concentrations
c) pesticides, herbicides, heavy metals, detergents, fertilizers, sewerage, silt, coal dust, air pollutants, etc.

Try to use the concentrations which are actually occurring in the water in your area.

Questions:

Why do you need a control? Were all containers placed under the same conditions: (light, temperature, size of jar, amount of water, etc.)? How many animals are needed to test a pollutant? Were 10 per container enough, too many, or not enough? Did all of the hydras come from the same container? How long should the test run? How long would the pollutant you were using stay in the natural water habitat? Did you feed the animals? Did you note differences in feeding behavior? Did you note differences in ability to move? How often did you disturb the containers? Was every container subject to the same amount of disturbance?

WINTER CONSIDERATIONS

Problem 1 could not be conducted in winter unless you have access to a body of water which remains ice-free and warm all year round. Problems 2 and 3 could be conducted in the winter if a supply of hydras was available.

PROJECTS USING PLANARIANS

GENERAL METHODS:

COLLECTING:

Planarians should be found in the uppermost one or two centimeters of the bottom debris of ponds (sloughs) as well as in the algae and rooted vegetation from any body of fresh water. Place the material in a wide-mouthed jar or aquarium. Let it sit for 6 to 12 hours. Many of the specimens will migrate to the surface of the container and may then be picked up with a pipette or eye-dropper. The worms may continue to seek the surface on subsequent days if the containers are left undisturbed. Extra water should be collected for culturing purposes.

EQUIPMENT:

Glass jar, pipette or eye-dropper.

CULTURING:

a) Short term (1 - 2 weeks). Initially keep the animals in the water in which they were collected. Discard the debris. Try to keep the water clean adding only a few pebbles and some clean, fresh green aquatic plants. Cubes of fresh meat (beef liver, earthworm fragments, chopped meal worms) fed once or twice a week should supply the food required. If they do not respond to the meat, place some decayed bottom debris in the culture. Change the water and remove all meat and organic debris two to three hours after feeding.

Remember to use pond water or aged tap water. Keep the culture cool and dark.

b) Long term. A small aquarium. (Appendix A-5)

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. Do flatworms have a habitat preference?

Suggested Design:

Collect an equal amount of organic material from:

a) different parts of the same habitat. For example, collect ¼ quart of algae, ¼ quart of bottom debris, ¼ quart of rooted vegetation, and ¼ quart of a mixture of any of the above.

b) a number of different habitats.

For example, try:

- i) a dugout, a slough, a lake, and a stream;
- ii) at the shore, in 6" of water, in 1' of water;
- iii) on the sheltered side of the body of water, on the windward side;
- iv) mud bottom, sand bottom, gravel bottom. Record the oxygen (Appendix A-1), the pH (Appendix A-6) and the temperature of the water in each habitat. Record the number seen at the time of collection, 6 hours after collection, 12 hours later, 24 hours, 48 hours, 72 hours, etc. After counting transfer animals from the original collection to a clean container.

Questions:

How many samples did you collect at each site? How many readings did you take at each site? For example, did you record the type of substrate, i.e. mud, sand, or gravel? How many chemical readings did you take at each site? For example did you record the temperature, pH and dissolved oxygen of the water? Did you note the biological conditions of the water? For example did you record the kinds of plants and animals seen? Did you find any correlation between the substrate, the vegetation, one or more of the readings (e.g. oxygen), and the number of flatworms in the sample? Could you determine from your data the preferred habitat of the planarians? Did you discover certain factors which may limit where these flatworms can live?

PROBLEM 2. To determine why planarians do not live in certain waters.

Suggested Design:

Vary one condition which you think may be the one which determines where planaria can live. For example, vary the temperature, the intensity of light, the number of planaria per test container, the amount of bottom debris, the kind of bottom debris, the amount and kind of shelter, the pH, etc. Observe for at least one week.

Questions:

Did you have a control? Did you check to see that you were testing only one variable at a time? Did you have an equal number of planaria per test container? Did you have replicates? Did you check with natural field conditions to see if your conditions were those found under field conditions? Were the best conditions as determined by laboratory results the conditions under which you or someone else found the most planarians in the field? (see Problem 1).

PROBLEM 3. More questions requiring experimental answers.

a) How do these worms move?

b) How do they react to light?

WINTER CONSIDERATIONS

Problems 1, 2 and 3 could be conducted in winter. Collecting as outlined in problem 1 would probably have to be restricted to fewer habitats. One of the areas in which collecting should be attempted would be the shallow portions of weedy bodies of water. A sample of mud and vegetation from slough bottoms in areas close to shore should prove interesting. The procedure for collecting this mud sample would be the same as that outlined under "Winter Considerations" in the outline for "Projects Using Protozoa".

PROJECTS USING EARTHWORMS

GENERAL METHODS:

COLLECTING:

It is best to enquire locally and find someone who knows where these animals may be found. A digging tool of some form may be required.

EQUIPMENT:

Digging tool (spade), paper bags for transporting and newspaper for assistance in the counting.

CULTURING:

a) Short term (one to two weeks). Place the animals with the soil in which they were gathered in a wooden box or if necessary in a cardboard box. Try to add some decaying organic material such as old leaves. Keep soil damp but not wet. Keep away from direct sunlight.

b) Long term. Construct a wormery - see Appendix A-7.

SUGGESTED PROJECTS

Select one, any number or all of the following as a project.

PROBLEM 1. What are some of the factors which determine where earthworms live?

Suggested Design:

Record the number of earthworms per square foot of surface area in an area where you know or suspect their presence. Do you think sampling per cubic foot would be more accurate? Test it. Compare the number found in this area or volume with the number collected by the same method in any, some or all of the following areas:

a) north side of a building vs. south side of a building;

b) under the eaves and at measured distances away from the building;

c) in a garden, in a lawn, in the border between the garden and the lawn;

d) near walkways and at measured distances away from walkways;

e) in some woods, in the grass next to the woods, in the border between the woods and the grass;

f) in sandy soil, in clay soil, in humus soil, etc.;

g) on a shore, ten feet from the shore, twenty feet from the shore, etc.;

h) in the top three inches of soil, in the top six inches of soil, etc.

Questions:

Do you think earthworms have a preference for certain habitats? Do you think they can live in all habitats? What factors do you think might be involved in survival or habitat preference? How are worm numbers related to the season, to wet versus dry spells? Can you test the importance of temperature, moisture, soil structure, food as limiting factors in both laboratory, and field?

PROBLEM 2. How do earthworms change the soil?

Suggested Design:

Establish one or two wormeries in two quart sealers by filling each sealer nearly to the top with equal layers of

a) one-third sand on the bottom, one-third leaf mould in the middle and one-third loam on top. Place some food on top; for example, dead leaves, small pieces of carrots. Put a set number of apparently healthy worms (e.g. four) in each container. Keep damp but not wet. Cover the entire sealer with a dark cloth when not observing the worms. Record earthworm behavior, time and number of survivors, daily. Record also any change in the order of layers in the soil.

b) Repeat part (a) but this time change the order of layers in the wormery. Use several different combinations.

c) Repeat part (a) using only two layers in the jar.

d) Repeat part (a) using any material in any combination which you think the earthworms might encounter in nature.

Questions:

Does the soil determine whether earthworms are present or do the earthworms determine what soil is present? What is the role of earthworms in the ecosystem? How do they help other plants or animals? Can you experimentally determine their role in phenomena such as water conservation, nutrient recycling, mineral recycling, or energy conversion?

PROBLEM 3. To determine some effects of physical and/or biological conditions on earthworm numbers.

Suggested Design:

a) Change the physical conditions and record earthworm behavior and layer change, if any. Observe daily for at least two weeks. For example, you may vary:

  1) the temperature by using a refrigerator, a basement, and the classroom;
  2) the moisture - dry, damp, or wet;
  3) combinations of moisture and temperature.

b) Change the biological conditions and repeat observations. For example, vary the number of earthworms per container, or the amount of food per container.

Questions:

What happens when you:

a) put ten worms in a container the size of a jam can and twenty in another similar container?

b) repeat (a) placing both containers under different environmental conditions (e.g. temperatures).

Did you have a control for each experiment? Do earthworms eat more or less when they are cold? Do earthworms move soil faster or slower when they are cold?

PROBLEM 4. What are some effects of biocides on earthworms?

Suggested Design:

Establish as many wormeries as are needed (see Problem 2) and record the change if you:

a) spray one with a herbicide at the recommended dosage (e.g. for thistle control);

b) spray one with an insecticide at the recommended dosage (e.g. for cutworm control);

c) vary dosages or mix both the herbicides and the pesticide.

Questions:

Did you have a control wormery? How many times did you repeat the test? Does spraying to control a pest species hurt only that one animal? If not where does the spray go? Does it go into the air, the water or onto the soil? What happens to it? If some earthworms should die as a result of ingesting biocide what would happen to the biocide? Would it stay in the earth? Could it get into the food chain? How? What other kinds of animals may eventually get some of it? Literature research might provide some answers to these questions.

PROBLEM 5. More questions requiring experimental answers.

a) Do earthworms ever drown?

b) Can earthworms hear? If so, what can they hear; music, voices, vibrations?

c) Can earthworms learn? If so, do young earthworms learn more rapidly than old earthworms?

d) Are young earthworms born alive or from eggs?

e) What do earthworms do when winter approaches?

f) Do earthworms breathe?

WINTER CONSIDERATIONS

Problem 1 could not easily be conducted in winter. Problem 2, 3, 4 and 5 could be conducted in winter if a supply of earthworms was available.

PROJECTS USING AQUATIC EARTHWORMS

GENERAL METHODS:

COLLECTING:

Aquatic earthworms such as members of the Family Tubificidae can be obtained by collecting the mud in which they live. They have the same fundamental structure as the common terrestrial earthworm, therefore they look like miniature terrestrial earthworms. They can be washed free of the mud by placing the collected material in cheese cloth or in the nylon stocking-coat-hanger-net (Appendix A-8). Hold the net together at the top, and swish gently in the water. This should remove most of the mud and leave you with the animals. Invert the cloth or net over a flat container such as an enamel pan and gently back-pour so as to wash the animals into the pan. Back-pouring means to pour a little water (pond or aged tap water) on to the back of the net. Do not pour in too much of the muddy water at one time or you will not be able to see the animals on the bottom of the pan.

CULTURING:

a) Short term (one week). Place ½ inch layer of mud containing the worms in a pint sealer. Cover with ½ inch layer of sand. Fill the container with pond or aged tap water. Place in moderate but not direct light.

b) Long term. Use the same arrangement. However, change the water weekly and occasionally add some more mud.

SUGGESTED PROJECTS

Select one, any number or all of the following as a project.

PROBLEM 1. Where are the worms?

Suggested Design:

Collect equal sized samples of mud from three different habitats: foul smelling water, dugout or slough, and fresh water (creek). Take at least two standard samples (tin cans?) from the surface of the mud, 4" under the surface and 6" under the surface. Determine the approximate number of aquatic earthworms in each sample.

Questions:

Where were the most worms found? Why? Can you find a relationship in the field between the number of worms you found and measurements such as the temperature of the mud and/or the oxygen content of the water where found?

PROBLEM 2. How does pollution affect the worms?

Suggested Design:

Establish as many short term cultures as are needed for the following project. Attempt to place approximately the same number of worms in each. Observe the cultures daily for a set period (10 minutes) without disturbing the containers or the table on which they sit. Record a) the average proportion of the body sticking out of the burrow and b) the number of oscillations per minute of the part sticking out. Observe for at least two weeks. Record the behavior if:

a) A steady reduction of oxygen occurs. A polyethylene bag 3/4 full of sour cream placed on the surface of the water will help reduce the oxygen at a steady rate. Why? (Appendix A-12)

b) Inert pollution occurs (silt, coal, etc.). For example, add one inch of sand to the mixture every two days.

c) Toxic pollution occurs (e.g. pesticide, herbicide, oil, copper, chloride, sulfur, etc.). Attempt to choose some that are actually occurring in your area.

d) Organic pollution occurs. For example, add one inch of commercial fertilizer or barnyard manure or mashed up household garbage (bananas, coffee grounds, etc.) every two days.

Questions:

What happened to the oxygen levels in each of the above? Did you find a correlation between the length of the worm and the oxygen level? Did you find a correlation between the number of oscillations per minute and the oxygen level? What is the purpose of oscillating in these earthworms? What was the pH? Was the kind and the amount of pollution realistic? Did you check with the local sewage engineer? What is the role of aquatic worms in pollution control? What happens if you mix two or more of these pollutants? How might you be affected if all of the aquatic worms in your area were killed?

WINTER CONSIDERATIONS

Problems 1 and 2 could be conducted in winter. Some species may be reduced in number or may even encyst in late fall or winter when the water temperatures are reduced. You could collect bottom debris and mud from bodies of water, i.e., sloughs, in winter and simulate summer conditions by culturing the material at room temperature. The procedure for collecting mud as outlined in "Winter Considerations" in the "Projects Using Protozoa" section could be helpful for this project.

PROJECTS USING LEECHES

GENERAL METHODS:

COLLECTING:

Specimens can usually be collected only individually. They are often found under rocks, logs, and debris in the shallow parts of the lakes, sloughs, and dugouts. A small dip net should be carried to help capture the rapid swimmers and to retrieve sluggish leeches as they roll up and fall to the bottom (Appendix A-8).

EQUIPMENT:

Dip net, plastic bags or glass sealers, forceps, garden rake.

CULTURING:

a) Short term (1 week). Leeches may be kept in the water in which they were collected. A quart sealer is a handy container for short term culturing and observing. Fill the container ½ to 3/4 full of water. Add some aquatic plants, a few small rocks and some floating wood. Keep the top covered tightly with a fine meshed cloth to prevent the escape of the more active leeches. Keep in a cool dark spot. Try to keep different species in different containers.

b) Long term. The long term culturing method depends on the family of leeches captured. They can all be kept in a mini-aquarium (Appendix A-4) if the culture water is kept cool, dark, and clean. (Remember, if you must use tap water, let it stand for 2 days before adding to your culture.) However, they require different food as indicated.

Family Glossiphonidae - add living snails

Family Erpodellidae - add fresh ground meat

Family Hirudidae - feed earthworms, frogs eggs, immature insects, etc.

If you don't know which family you have, provide the leeches with a sample of food for each group and let them choose.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. What is the preferred leech niche within the aquatic habitat?

Suggested Design:

Select a habitat such as a slough, dugout, lake, etc.

Look for and catch all leeches resulting from:

a) pulling ten cattails out by the roots and/or

b) collecting ten handfuls of another type of an aquatic plant and/or

c) making ten standard, uniform sweeps through the surface of the water with a dip net and/or

d) making ten sweeps with the dip net as close to the bottom of the water as possible and/or

e) collecting ten handfuls of mud from the bottom (or some standard measure such as ten tin canfuls.

Questions:

Was your collecting all done in the same depth of water? Did you collect from only one type of substrate - mud, sand? Did you find leeches in all of the areas sampled? Did you find different kinds of leeches in the different habitats? Did you find different numbers of leeches in different habitats? How did you sort them into families? If your school doesn't have any books which will help you then you might try making your own key. You might try classifying according to size of mouth, number of annuli per segment, color of blood, shape of body - whether flat or cylinderical, and number of pairs of eyes. Did you find the same habitat preferred by all leeches? Did you find different preferred habitats for different kinds of leeches? Could you design a laboratory experiment whereby you would give a leech a choice of habitats to see if your field observations can be supported with laboratory data?

PROBLEM 2. High noon or midnight - when are they about?

Suggested Design:

Choose a study area which you know is a good leech area. Select a sampling method (see Problem 1) and sample in the morning, at noon, at dusk and after dark.

Questions:

How many times did you repeat your sampling? Did you always sample from the same area? Did you remove captured leeches or return them to the sample area after recording the numbers? How would this affect your results? Did you get the same number and the same kind of leeches at all times of the day? Could you design a laboratory experiment to determine if your field observations can be supported with laboratory results?

PROBLEM 3. Is a leech a bloodsucker?

Suggested Design:

Collect leeches from any chosen area. Record the presence and relative abundance of any animals which you think may be supplying blood meals for the leeches. Attempt to collect your choice of the most likely victim (if legal and possible to do so). In the laboratory provide your collected leeches with an opportunity for a blood meal. Give them at least two 15 minute choices of any or all of the following:

a) your finger and the animal collected;

b) animal, finger and a living snail;

c) repeat above, plus fresh ground meat;

d) repeat above, plus a living frog or toad or frogs' eggs or immature insects (e.g. mosquito larvae).

Questions:

How do you explain the results or lack of results? When do leeches normally eat? (In the day or at night?) How often do leeches eat? Where do leeches fit into the food web?

PROBLEM 4. Is space a limiting factor for leeches?

Suggested Design:

Vary the number of leeches in different containers, (e.g. 20 or 10, etc. per pint jar). Keep all other conditions as outlined in the culturing methods the same for all containers. Observe for a 10 minute period daily for a period of two weeks. Record behavior and number of deaths in each container.

Questions:

Were deaths related to density per container? Did you have a mixture of different species in the same container, or different species in different containers? How would this affect your results? Did you always observe the animals at the same time of day?

PROBLEM 5. Leeches and snails. Which is predator? Which is prey?

Suggested Design:

Set up a series of containers containing leeches and snails in the following ratios: 4:1; 2:1; 1:1; 1:2; and 1:4. Try to use the same kind of leeches and the same kind of snails for each series. Leeches in the family Glossiphonidae should be used. Observe daily for a ten-minute period and record all changes noted.

Questions:

Do the results indicate what happens in a pond? What are the differences and the similarities contrasted and compared with a pond?

What do you think controls the number of leeches in a pond? Did you attempt to determine if the ratio was important or the total number of animals in the container? For example, what happens if you try a series using the same ratio but different numbers - 1:4; 2:8; 4:16; etc.?

PROBLEM 6. What are some effects of pollutants on leeches?

Suggested Design:

Place a number of leeches (e.g. 2) per container in all or in one of the following possible pollutants.

a) 5 different concentrations of chlorine (household bleach). For example 1.0 mg/l, 2 mg/l, etc. Observe for one week and record the results.

b) 5 different concentrations of copper ($CuSO_4$, bluestone). For example, 0.5 mg./liter, 1.0 mg./liter, 1.5 mg./liter, etc. Observe for one week and record the results.

Questions:

Did you have a control? Did you use natural water or tap water? Were all variables controlled; e.g. size of container, amount of water, size of leech, etc.? Why do you think chlorine and copper are good choices as pollutants? Where is chlorine used? Where does it go after use? How is copper in the form of copper sulphate (bluestone) used? Could you explain the connections between leeches, snails, swimmer's itch, copper sulphate and pollution?

PROBLEM 7. More questions requiring experimental answers.

a) How do leeches see?

b) Why are leeches different colors?

c) How do they reproduce?

d) Do they react positively, negatively, or not at all to stimuli such as light, temperature, disturbance of water, etc.?

e) What are the adaptive advantages to the leech if it reacts in one way or another to each of the above stimuli?

f) How does a male find a female?

WINTER CONSIDERATIONS

It would be difficult to conduct problems 1, 2 and 3 in winter. Problems 4, 5 and 6 could be conducted in winter if leeches were available. A suggested winter project could be to determine if leeches can be collected in winter. Collecting a measured amount of mud from a normal summer habitat, i.e., a weedy area close to shore, adding water and watching developments could be fruitful. The procedure for collecting mud as outlined in "Winter Considerations" in the "Projects Using Protozoa" section could be helpful for this project. You may also attempt to gather frozen substrate and substrate below the frost line in an attempt to determine where leeches spend the winter. A strong back and a good axe or pick would, of course, be necessary for this type of project.

PROJECTS USING POND CRUSTACEANS

(Order Ostracoda, e.g. seed shrimps; order Copepoda, e.g. "Cyclops"; order Cladocera, e.g. water fleas; order Amphipoda, e.g. scuds, sideswimmers.)

GENERAL METHODS:

COLLECTING:

These animals are common in small bodies of water such as ponds, sloughs, dugouts and shallow lakes. Generally they can be captured by drawing or swishing a net (Appendix A-8) through the rooted plants in the shallow portions of these habitats. For some it may be necessary to skim the surface debris on the bottom or even scoop up some of this bottom debris. If this is necessary try washing out some of the mud by holding the net closed at the neck and swishing each sample through the water a few times before placing in the sorting pan. It is often best to try to sort and identify the animals at the time of collection rather than waiting to do this in the laboratory.

CULTURING:

a) Short term (one week). Most can be maintained, with varying degrees of success, in glass jars (battery jars, two quart sealers, etc.) of pond water with a bottom layer of mud, dead leaves and well decayed bottom debris. Add fresh water periodically and keep the culture cool, even refrigerated.

b) Long term. The same as for short term except add some method of providing oxygen either by gentle aeration, photosynthesis, or regular addition of well oxygenated water.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. What, where, when and how many will you capture?

Suggested Design:

i) Select one aquatic habitat and take at least five dip net samples each from as many different areas as you can find; for example,

   a) mud bottom, sand bottom, gravel bottom
   b) rooted plants, floating algae, clear water
   c) sheltered area, wind swept area
   d) shallow water, deep water
   e) at the surface, at the bottom and every six inches in between
   f) in different plant types
   g) at the shore, one foot from shore, and/or

ii) Select a number of different kinds of aquatic habitats (e.g. slough, lake, etc.) and take at least five dip net samples from the same type of environment (e.g. same type of plant in each) in each habitat.

Questions:

Did you use the same sampling technique in each area sampled? Did you draw the net the same distance each time so as to sample the same volume of water? If not, did you correct for this error when you compared the type and number of animals found at each site? Did you sort all samples in the field or all in the laboratory? If you sorted some in one place and others in another can you compare the kind and number of animals found in each area sampled? Did you introduce a sampling error at any point in your sampling? For example, did you take all of the samples at about the same time of the day? Did you attempt to determine the effect of light on the distribution of the animals? Do they always stay at the same level in the water?

Were some of the animals associated with certain plants? If so, did you discover why? Were they feeding directly on the plants? Were they feeding on another animal which was feeding on the plant? Did you discover the most productive part of a habitat?

PROBLEM 2. What happens when you change living conditions?

Suggested Design:

Collect animals from any or all of the habitats suggested in problem 1. Record if possible the temperature, pH (Appendix A-6), and oxygen content (Appendix A-1), of the water from which you collect the animals. Establish as many cultures as are needed in small glass jars such as pint jars. Try to use the same number of animals (e.g. 10) and the same kinds of animals in any set of cultures you wish to compare. Then attempt to determine their reaction to any or all of the following. Do not forget a control container in every case. The field recordings should help you determine normal conditions.

1. Light. Cover the containers with a black material, leaving a light hole on top for one container and on the bottom for another, or place the containers in a dark room with a small light spotlighting different parts of different containers. Observe for at least 15 minutes.
2. Drying up. Have at least two containers, one with a two-inch layer of mud and one without a layer of mud. Allow them to dry up completely. After one week, pour the same amount of pond water or better, aged tap water into each container. Observe for at least a week, recording the appearance of any life.
3. Freezing. Repeat the drying experiment this time freezing the water. Plastic bag containers should be used.
4. Temperature. Maintain a series of containers at different temperatures. Observe for at least two weeks.
5. pH. Same as temperature experiment.
6. Variation in numbers. Place different numbers of animals of the same kind in different containers of the same size (e.g. 10, 20, 50, etc.). Observe and record numbers of animals daily for at least two weeks.
7. Variation in species. Place different groups together in different jars. For example, place sideswimmers with seed shrimps, and water fleas with sideswimmers, etc.

Observe and record results for at least two weeks.

Questions:

Did you determine what the normal conditions are in the water from which these animals were collected? Do these conditions remain stable throughout the year or do they change with seasons? For example, is the pH in a small temporary slough the same in spring, in summer and in fall (or just before drying up)? Did you test to see if the kind and number of crustaceans found in a small temporary slough can be correlated with the change in pH? In all of the above suggested experiments did you attempt to see how a particular behavior pattern or reaction may be advantageous to the animal in its natural surroundings? For example, if some animals react positively to light, that is move toward it, how would this reaction help its survival in the world in which it lives?

WINTER CONSIDERATIONS

Problems 1 and 2 could both be excellent winter projects. Ask your teacher for more information regarding the collecting and culturing of winter samples for these projects. You may attempt to collect a measured amount of frozen mud (debris) from the edge of an aquatic environment where the water has receded, or from the dry bottom of a temporary body of water.

PROJECTS USING GRASSHOPPERS

GENERAL METHODS:

COLLECTING:

Grasshoppers can be collected with a net (Appendix A-8) either by sweeping the vegetation or by aiming at particular individuals.

CULTURING:

a) Short term (1 - 2 weeks). A container such as a jam jar (can) covered with a fine meshed cloth (cheese cloth) is quite suitable. Treat in the same manner as the long term culture.

b) Long term. A grasshopper cage should be built. This could be a wooden frame (about 18 x 24 x 12 inches) covered with wire screening. Some earth or sod should cover the bottom of the cage and this should be kept moist but not wet. Fresh plants for food should be provided daily.

SUGGESTED PROJECTS

Select one, any number or all of the following as a project.

PROBLEM 1. What are the prime living areas for grasshoppers?

Suggested Design:

Collect and record the number of adult grasshoppers from all or some of the following areas. Collect by sweeping each area with a sweep net (Appendix A-8) a set number of times (e.g. 10 sweeps per area). If you wish to keep some, twist the handle of the net to close the net at the end of every sweep and transfer total contents or just the grasshoppers to a plastic bag. Suggested areas might be a roadside ditch, borders of sloughs, banks of irrigation ditches, pasture, sod, stubble field, native grass area, etc.

For comparison you may wish to try:

a) in grass, in woods, and in the border between grass and woods.

b) in summerfallow, in grass, and in the border between these.

c) in a roadside ditch, in the field next to the road, and in the border between.

d) at the edge of a slough, and at regular intervals from the edge.

Questions:

Did you use the same net in each area sampled? Did you sample all areas on the same day, and at about the same time of day? Did you use the same method of closing the net in each area sampled? Was the length of the sweeps the same in all areas sampled? Did one person or more than one sample the areas used for comparison? Did you discover where grasshoppers prefer to live? Did you discover why there are more grasshoppers in one area than in another? Was it because of available food, shelter, lack of predators, water, soil type? Could you determine the limiting factors with laboratory experiments?

PROBLEM 2. To determine some factors which are responsible for changing the number of grasshoppers in an area.

Suggested Design:

One method might be to select a measured study area and to take a set number of sweep net samples (e.g. 5) every 2 or 3 days for a period of two weeks. Record any physical or biological data which you think might be controlling the numbers (e.g. air temperature, soil temperature, precipitation, number of predators, amount of food, etc.). Make sure you release the grasshoppers at the site after counting. You may attempt to mark the captured grasshoppers (finger nail polish) so that you can determine the total population by the capture-mark-recapture method (Appendix A-9).

Questions:

Did you discover any principle which may explain the reason for a sudden increase in the total number of grasshoppers in an area? Based on your data what would be the best method of controlling grasshopper population explosions? How is it actually done in an area close to you? Is this the most effective way considering both the ecological and the economic point of view?

PROBLEM 3. Grasshopper control - must it be economics versus ecology?

Suggested Design:

Grasshoppers are listed as an agricultural pest. Therefore different methods are used in an attempt to control their numbers. The most common are starvation (summerfallow) and pesticides. Could you design a series of laboratory experiments to attempt to determine the most effective method of controlling these pests? To do so, you may have to find answers to some of the following questions:

Questions:

Where do grasshoppers lay their eggs? Where do they spend the nymph stage of their life? How long does each stage last? At what time of the year is each stage the most common? What determines when they will change from one life stage to another? At what life stage using what method would it cost the least to control them? At what life stage using which method would the control method harm the ecological system the least?

PROBLEM 4. More questions requiring experimental answers.

a) How do grasshoppers sing? What is the purpose of the "singing" action?

b) Is there any interaction if you put ten male grasshoppers and ten female grasshoppers in the same cage?

c) Why do grasshoppers migrate?

d) How much food (dry weight) can a grasshopper eat per day? How much per life time?

WINTER CONSIDERATIONS

The problems suggested are suitable for spring and summer and not for winter. A winter project could be to attempt to collect and raise grasshopper eggs. The eggs are generally laid on egg beds located in roadside sod, borders of sloughs, or scattered throughout stubble fields, etc.

The collecting would best be done in fall but could be done in winter. The best time to collect eggs in Alberta is late September through October. Eggs can be collected by going to a high grasshopper infestation area and digging in the soil. Contact a Department of Agriculture District Agriculturist to find the best area. The soil then should be sifted through a sieve and the eggs, which are found in collections called pods, should be visible. The egg pods, which measure about 1/4" by 1" and contain 20-30 eggs, are generally laid 1" to 2" below the soil surface. Put the pods together with some moist sand in containers such as petri dishes and keep these at a temperature of about 5°C (40°F) for about two months. Most grasshopper eggs require cold conditioning before they will hatch. A good winter project would be to determine the hatching success without cold conditioning or with cold conditioning for different lengths of time, i.e., 1 week, 2 weeks, 3 weeks, etc. Remove the egg pods from the cold and place them in a screened wire cage at room temperature. The eggs should hatch in about one to two weeks. The first instar should last about two hours after hatching and the following molts should occur at about 1 1/2 to 2 week intervals.

PROJECTS USING COCKROACHES

GENERAL METHODS:

COLLECTING:

CAUTION: Wash your hands well with soap after handling cockroaches. A number of diseases may be carried by this animal.

A cockroach trap such as the one shown in Appendix A-13 may be used. Glue or tape a paper cone into the metal ring of a fruit jar. Cut off the tip of the cone to leave an opening about half an inch in diameter. Smear the cone on its outer surface, about halfway between the tip and the ring, with a ring of vaseline. Place some bait in the jar (ripe banana) and replace the ring with the cone attached. Place the jar on its side so that cockroaches may enter the trap easily. To empty and rebait simply unscrew the top.

EQUIPMENT:

Quart sealer, paper, glue, vaseline, ripe banana.

CULTURING:

Cockroaches can be cultured in various types of containers. A large glass jar or plastic jar covered with a fine mesh cloth (cheese cloth), or even an open box, provided the box is several inches deep and the upper two or three inches of the sides are smeared with vaseline, is fine. Keep dark, provide water and scraps of any type of food - bread, fruit, vegetables.

PROBLEM 1. Where is your home, roach?

Suggested Design:

Attempt to collect cockroaches using various possible methods.

For Example:

a) place one trap at the same site for three successive nights; and/or,

b) place traps at different locations for three successive nights.

For example: basement, kitchen, living room, classroom, garage, garbage pile, barnyard, nuisance grounds, etc.

Then either;

a) record the number of roaches caught per trap and release; and/or,

b) record the number of roaches caught per trap and keep them for culturing; and/or,

c) record the number of roaches caught per trap, mark each (with a dab of fingernail polish using different colors and different number of dots), release, and record recapture (Appendix A-9).

Questions:

Did you determine the preferred habitat of roaches? Was there a change in the number of roaches caught per trap per night when captured with the different methods? What kind of cockroach did you get? What was the ratio of males to females? Were any females carrying eggs? If so, how many eggs per female? How many do you think might survive to the nymph stage and how many to the adult stage? Did you calculate this from your data? How many cockroaches do you think would need to enter a building in order to infest the whole building in one year?

PROBLEM 2. Why do you like your home, roach?

Suggested Design:

Collect cockroaches by any successful method. Establish a number of cultures changing one condition in each to determine what conditions roaches like. For example, change the temperature, the food, the moisture, the light, and the number of hiding places. Record behavior, time of death and number of deaths per culture. Observe for at least two weeks. You may wish to use a maze giving the roaches a choice of conditions.

Questions:

What is the role of the cockroach in the ecosystem? What eats cockroaches? How is the population naturally controlled? How does man try to control the population? From your data could you determine the best method of control? Would you control the eggs, the nymphs or the adults?

WINTER CONSIDERATIONS

The problem suggested could be conducted in all seasons including winter.

PROJECTS USING AQUATIC BUGS, BEETLES, DRAGONFLIES AND DAMSELFLIES

GENERAL METHODS:

COLLECTING:

These animals are widespread in ponds, sloughs, lakes, streams, and rivers. They can easily be collected by sweeping a net (Appendix A-8) through heavy aquatic vegetation in the shallows near the shore. For some (e.g. beetles) it may be advantageous also to sweep the net over the bottom of the bodies of water. Windswept shores or deeper waters of lakes and rivers are generally poor sampling areas. Separate the animals into groups of similar kinds soon after collecting.

EQUIPMENT:

Net, plastic bags or quart glass sealers.

CULTURING:

a) Short term (one to two weeks). Place animals from each of the above groups into separate containers each filled to the 3/4 mark with the natural water or aged tap water. Add ½ inch of sand and a few fresh, green aquatic plants. Keep the container cool. For food see problem 1 or ask your teacher.

b) Long term. They can be maintained in an aquarium (Appendix A-4 or A-5). Fish should not be a part of the aquarium.

SUGGESTED PROJECTS:

Select one, any number, or all of the following as a project.

PROBLEM 1. What do these animals eat?

Suggested Design:

Collect some of the above animals. When collecting note and record the kinds and relative abundance of possible food sources. Collect samples of the most abundant. In the laboratory: a) separate test animals into different containers as suggested in the short term culture method; and, b) set up one culture containing all of the animals collected. Daily, for at least a week, provide test animals with a choice of possible food. Observe test animals at feeding time and again a few hours after feeding time. Remove uneaten food at this time.

Questions:

Did you always feed test animals at the same time of the day? Did you test to see if they prefer to eat during the day or at night? Did the test animals eat only one kind of food? Did they eat the same food in the mixed culture as in the pure cultures? Can you construct a food web based on your field and laboratory observations? What do you think eats your test animals? Can you design an experiment to test this?

PROBLEM 2. How do these animals breathe?

Suggested Design:

Collect as many different kinds of animals from the above groups as you can find (e.g. backswimmers, predaceous diving beetles, water boatmen, etc.). Place each group in a separate container as suggested in the short term culture method. Observe daily for a set period of time (e.g. 15 minutes). On the basis of your observations determine where and how the animals breathe.

Questions:

Was 15 minutes a day long enough for accurate observations? Did you attempt to completely exclude access to atmospheric oxygen or exclude all oxygen from the water? What anatomical and behavioral adaptations to the aquatic habitat did you observe?

PROBLEM 3. How well do these animals survive a cold winter or a hot summer?

Suggested Design:

Try to collect at least six animals per test group. Test the animals for at least one week at different temperatures (e.g. below freezing, cool, room temperature, direct sunlight, etc.).

Questions:

How many times did you repeat the test with the same animal? How many duplicates did you have in your test? Did you control all other variables except the temperature (light, oxygen, pH, etc.)? Did you have a control container? Did you record the normal daylight and night-time temperature of the water from which you collected your test animals? Did you vary the daily temperature of the test water? How did your experimental design differ from that which actually happens in nature? Did you determine possible ways these animals may adapt to the extreme temperatures? Could you test this in a long term field project?

WINTER CONSIDERATIONS

All of the problems could be conducted in winter. Ask your teacher for suggestions for locating the animals in the winter season. Correlating the animals found with the type of habitat in which they were collected could be a separate winter project.

PROJECTS USING TERRESTRIAL BEETLES

PROBLEM 1. What is the role of some beetles in the ecosystem?

Suggested Design:

Place a number of different substances in an area where beetles may be present. Cover the substances with a wire screen, staking the corners down firmly, to prevent removal of substance by cats, dogs, rodents, etc. Record daily the type and number of animals seen both on the substance and under the substance. The experiment should continue for at least two weeks.

You may wish to use some or all of the following suggested substances; a banana peel, banana fruit, a piece of wood, a freshly killed mouse, bread, honey, meat, glass, metal, paper, plastic, flower, etc.

Questions:

Were your samples all the same size? What type of animal was first noted? What sensory organ likely or probably helped them find the substance? Which of the substances showed the first sign of decay? What part of the substance decayed first? What remained after two weeks? Did different animals work on and underneath the substance? What percent of all animals counted were found to be beetles? How large were they? If you calculate the weight or size of all animals gathered what percent would be beetles? How much did the beetles eat when compared with the other animals? Did you test this in a laboratory experiment? What would happen if you enclosed an area to prevent beetles from coming into the area, sprayed the area to kill all animal life in the area, and then placed the different substances in this area? Try this. Can you propose a definition of pollution based on this experiment?

WINTER CONSIDERATIONS

This project is not suitable for winter.

PROJECTS USING CASE-BUILDING CADDIS FLY LARVAE

GENERAL METHODS:

COLLECTING:

These animals are best collected in marshes, ponds, sloughs, lakes and streams. One method of collecting is to begin by carefully observing the bottom of a body of water. If you selected a quiet portion of water you may be rewarded by seeing what appears to be a piece of debris moving about jerkily. Carefully catch it with fingers, forceps or net (Appendix A-8). You have probably captured a caddis fly larva and case. Inside, largely hidden from view, will be the larva. Place the case in a container (plastic bag, glass jar, etc.) containing water from the habitat being studied. If left undisturbed for a few minutes the "case" will start walking.

Another method is to gather bottom debris and vegetation using either a net or a garden rake. Place this mixture in a container (e.g. bucket) for later sorting or in a shallow pan for immediate sorting.

CULTURING:

a) Short term (1 week). Place the animals in a mini-aquarium (Appendix A-4).

b) Long term. The animals should be kept in an aquarium (Appendix A-5), which is supplied with adequate oxygen by photosynthesis or by an aerator. Attempt to insure that the aquarium contains some algae, higher plants, small crustaceans, and/or small aquatic worms.

SUGGESTED PROJECTS:

PROBLEM 1. How does the larva choose its case-building materials?

Suggested Design:

Collect as many different kinds of cases containing living larvae as you can find. Note and collect some of the material used for case construction. In the laboratory separate the "cases" into different containers (e.g. pint jars). Then remove with forceps ½ of the case from the animal(s) you wish to use as your test animal(s). Provide these test animals with all or any of the following:

a) More of the same material previously used for its case, or,

b) A different natural material used by another caddis fly larvae, and/or,

c) A different unnatural material; for example, egg shells, paper, colored beads, different plants, etc.

You might try gently pulling the worms out of their intact cases and exchanging cases so that each will get a different kind of case. Observe and record results.

Questions:

How many different kinds of cases did you find in each body of water? Did you sample only one type of environment; i.e., a pond or a stream? Did you sample only one habitat in that water body; i.e. only muddy bottom or only gravel bottom? Did you note and record other possible building materials than the one you collected? Did you note the size of the building units? Did the worms select their material? What would be the adaptive advantage of a certain kind of case in each habitat studied? What do these animals eat? What eats these animals? Find out all you can about their life histories.

WINTER CONSIDERATIONS

Caddis fly larvae do live and grow all winter. However, collecting does present a problem and, therefore, the problems outlined are not recommended as winter projects.

PROJECTS USING CATERPILLARS (MOTHS AND BUTTERFLIES)

GENERAL METHODS:

COLLECTING:

a) Caterpillars. It is best to collect them individually as you see them.

b) Cocoons and/or Chrysalids. The best time to find these is in the fall or winter after the trees and bushes are bare of leaves. Some of them can then be seen hanging from the branches.

c) Adults. A butterfly net is standard equipment. If you are collecting for mounting purposes then a specimen should be killed quickly before it has time to damage its wings in the net.

CULTURING:

a) Caterpillars. Caterpillars may be reared in almost any sort of cage, provided the cage is cleaned and fresh food is provided regularly. The food to be fed can best be determined by noting the food the caterpillar was feeding on when you collected it. Offer it the same diet. If you cannot determine in the field what they are eating take samples of possible food and offer the caterpillars a choice of this collected material. You may wish to place the vegetation in a small container of water to help keep it fresh.

b) Cocoons and/or chrysalids. Construct a cage with a screened top or use a glass jar with a screened top as your cage. Cover the bottom with an inch or so of soil and then, after gluing the chrysalid or cocoon to twigs, insert them in the soil. Keep the soil damp at all times, but never dripping wet. Mildew should not be allowed to develop. Make sure the cocoons or chrysalids are hung in such a way that the adults will have room to unfold their wings when they emerge. You may wish to cut a small hole carefully in the cocoon to determine which side is up. Glue the hole shut after peeping.

c) Adults. These are difficult to culture. A screened cage is the first requirement.

SUGGESTED PROJECTS:

Select one, any or all of the following as a project.

PROBLEM 1. What and how much do caterpillars eat?

Suggested Design:

Collect as many different kinds of caterpillars as you can find. When collecting carefully note and record the type of vegetation being eaten by the caterpillar. Collect this vegetation for food. If you cannot determine in the field what they were eating take samples of possible food and offer the caterpillars a choice of this in the laboratory. In the laboratory feed your caterpillars as much food as they can eat. Record the type and quantity of food consumed daily.

You may wish to determine weight gain of the test animal.

Questions:

Did the caterpillars moult after you collected them? If so, how many times? Did they moult before changing to adults? Was the amount of food eaten the same before and after each moult? Was the type of food eaten the same after each moult?

PROBLEM 2. To determine some effects of starvation, over-crowding and temperature on caterpillars.

Suggested Design:

a) Starvation. Set up a series of jars each containing a set number of caterpillars (e.g. four). Vary the amount of food in each. Observe for at least two weeks and record results.

b) Overcrowding. The same as (a) except provide unlimited food but vary the number of caterpillars in each container.

c) Temperature. The same as (a) except this time the variable is temperature. You may wish to try a refrigerator, the basement, room temperature, by a window, outside in the shade, outside in the sun, etc.

Questions:

Did you control for all the variables except the one you were testing? Did you have a control container in all cases? From your experimental data could you determine if the natural control of caterpillars is density dependent or density independent?

WINTER CONSIDERATIONS

The problems as outlined are not winter projects. However, cocoons and/or chrysalids could be collected in the fall and some winter projects could be conducted with this collected material. A good place to check for butterfly and moth cocoons would be in old buildings. For example, one could determine the effect of different temperatures and different humidities on the rate of emergence of the same species of caterpillar. You would probably have to assume that one kind of cocoon would be one species. Another interesting project would be keep different cocoons under the same environmental conditions to determine the order of emergence.

A special winter project would be to attempt to determine the food preference of the Bertha Army Worm. In Alberta, cocoons can be collected in rape stubble in October or November. The cocoons should be packed in zonolite and placed at a temperature of zero to five degrees Fahrenheit for two and one half to three months. They should then be removed and warmed at 50°F for about two weeks and then placed at 70°F to 75°F. The adult should emerge and start laying eggs in about two to three weeks. They will generally lay the eggs on strips of wax paper if provided.. The larvae should be provided with different kinds of food immediately after hatching and until they change to adults. Some choices available to the larva in its natural habitat are rape, pigweed, cabbage, Canada thistle and wheat.

PROJECTS USING THE HOUSEFLY

CAUTION:

The common housefly Musca domestica is the vector of many diseases including dysentery, cholera and anthrax. The flies do not spread these diseases by biting; rather, they transfer the disease organisms with their feet and with their mouthparts. Therefore, try to avoid touching the flies with bare hands or letting the flies touch any part of you when you are working with them. In all cases wash well with soap after handling these animals.

GENERAL METHODS:

COLLECTING:

A number of methods could be used. (See Problem 1 for one method.) Collecting live flies with a net and transferring to a plastic bag is another method. A piece of refuse such as a rotten banana may help to attract the flies.

CULTURING:

A jam jar can be used to hold a housefly for studying its life and habits. Once the eggs have been laid on a piece of refuse, transfer the fly to another jar and place the eggs in a warm place in the sun or on a radiator. They should hatch in a single day or, at most, a week. Ask your teacher for further directions at this point.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. To determine some breeding limitations of the common housefly.

Suggested Design:

Gather as many containers of the same size as are needed for the project you choose. Fill each container with the substance(s) selected. Place at least 2 containers per substance at the sites chosen. Leave the containers uncovered for a set period of time (e.g. 24 or 48 hours). At that time tightly cover the containers with a fine mesh cloth. Remove to the laboratory or home and record daily observations such as appearance of maggots, number recorded, etc. Observe for at least 2 weeks.

Substances:

Fill one container to the 3/4 mark with dry soil only. Pack lightly.

Fill the second container 1/2 full of the same type of dry soil. Fill this container to the 3/4 mark with one of the following substances:

a) pure fermenting horse manure

b) horse manure mixed with straw

c) pure fermenting cow manure

d) cow manure mixed with straw

e) fresh grass clippings

f) fermenting grass clippings

g) dishwater

h) used coffee grounds, dry, moist and wet

i) fermenting vegetable refuse

j) a piece of raw meat, etc.

Locations:

Choose sites: a) at varying distances from a suspected source of flies (example - 1/8, ¼, ½, 1 mile, 1½, 2 miles) and/or b) having different light and temperature conditions; for example, north side of barn, south side of barn, in an open area, in trees, close to water, etc.

Sampling Methods:

Either place all of the containers with the different substances at one chosen site and compare results and/or place containers containing the same substance at different sites.

Raising Methods:

Place all of the containers of the different substances under one standard set of conditions (example: same temperature, same light, same humidity, etc.) and/or

Place containers gathered from the same spot containing the same substance under different conditions.

Questions:

Which substance contained the most eggs? How far from the suspected source of flies were the eggs laid? Did the maggots appear in all substances? What was the ratio of eggs to maggots where they did appear? What was the ratio of maggots to pupae? To adults? Did temperature affect the rate of hatching? Did moisture? What would happen if you had different sized containers with the same substance in each container? What was the natality and the mortality for your population of flies? What would happen if you left different containers (same size, same substance) exposed for different lengths of time? Did your experiments provide you with some basis for disease control? How? Test the effectiveness of your control methods through experiments. What would you recommend to be controlled? The eggs, larvae, pupae, or adults? Would you control the flies by attacking individual flies, by action against isolated communities, or by action against the total population? With what treatment would you control flies?

What is the effect of increased temperature on the eggs, larvae and pupae of flies? What is the likely effect of the heat and consequent increased temperature produced by compost piles or manure piles on the eggs, larvae or pupae? Did you test this?

What happens if you use layers of sand, the substance chosen and another layer of sand on top of that? Do flies still use this mixture as a breeding substance? If so, how do the pupae get out? Have you tested this?

WINTER CONSIDERATIONS

The problems suggested are not suitable for winter projects.

PROJECTS USING MOSQUITO LARVAE (WRIGGLERS)

GENERAL METHODS:

COLLECTING:

Mosquito larvae may be collected using a fine meshed dip net. Usually it is better if they are collected with a white cup or a white enamel dipper. In this way the water can be immediately examined for their presence.

EQUIPMENT:

Dip net - See Appendix A-8, white cup or white enamel dipper, plastic bags.

CULTURING:

a) Short term (1 - 2 weeks). Culture in a quart or pint sealer which is filled 2/3 full of the water in which you collected the larvae. Place a piece of wood on the surface of the water and cover the top of the vessel with any fine mesh cloth. A few pieces of plants put in the water may be helpful in keeping the water fresh. Why?

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. What is the source of these mosquitoes?

Suggested Design:

Select an area where mosquito control seems desirable. For example an area close to a house, a school or a town. Determine the number of mosquito larvae in this chosen area by any or all of the following methods:

a) Divide your chosen area into a grid (e.g. 10 feet between points). Locate any water which is close to the points on your grid (e.g. rain barrel, puddle, ditch, slough, lake, creek, etc.). Collect 5 cups of water from the surface of this water. Record the number of mosquito larvae from each cup of water collected and the total for the 5 cups of water collected; and/or

b) Walk a straight line collecting and recording the number of mosquito larvae from any water close to the chosen points. Choose your points at regular intervals, e.g. every 50 feet; and/or

c) Walk in ever increasing circles around your chosen area and collect at regular intervals e.g. 10, 20, 30, 40 foot radius from the school; and/or

d) Select different kinds of aquatic environments, collect and record the number of mosquito larvae from each environment.

Questions:

Did you discover the breeding water for mosquitoes? How far can mosquitoes fly? How could you mark the adult mosquitoes to see if they are the ones that are bothering you at your home or school? Vegetable dye? Fingernail polish? How would wind likely affect the flight pattern?

Did you do all of your collecting on one day? At the same time of day? All from the surface of the water? Did you always sample at the edge of the water? In the middle? In 2 inches of water? In 2 feet of water? How might weather, time of collecting and season of year affect your results?

PROBLEM 2. What is the connection between water temperature, rain and adult mosquitoes?

Suggested Design:

Choose one of the sites where you found mosquito larvae (see problem 1) and one where you did not find them. Sample these sites regularly (every 2 days) for a period of at least 4 weeks. Record the temperature of the water and the number of wrigglers found each time you sample. Record amount and time of rainfall during this period.

Questions:

Did you find a correlation between weather and mosquitoes? Did you find a correlation between water temperature and mosquitoes? Did you have more than one hatch of mosquitoes? Did you find a correlation between hatches and weather? If you recorded more than one hatch did the mosquitoes from the different hatches look like different mosquitoes? Could you find out how many different species of mosquitoes are found in your area by contacting your local mosquito control man or your District Agriculturist?

PROBLEM 3. Do mosquito larvae have any natural predators?

Suggested Design:

Choose a collecting method as outlined in project 1. This time record the number of phantom midge larvae (Chaoborus) as well as the number of mosquito larvae. See your teacher regarding the identification of phantom midge larvae.

Questions:

Did you find any connection between the two populations? Was there a set ratio of one to the other; for example, two mosquitoes for every phantom midge? Did you find one and not the other? Do you think one population rises as the other declines and vice versa? Could you combine problem 2 and 3 to determine if they both are connected in some manner with temperature fluctuations? Could laboratory experiments help you with this problem? Try them.

Did you note a correlation between when and where you found either mosquito larvae or phantom midge larvae and the number and kinds of birds in the area? Could you design a study to record if there is any connection? For a start you would have to find out when your birds are most active (morning, evening, etc.) and also whether they eat insects.

PROBLEM 4. Does everything that looks like a mosquito suck blood?

Suggested Design:

Raise mosquito larvae and phantom midge larvae collected from different bodies of water to adults in separate containers. Attempt to feed the adults a blood meal.

Questions:

Did you design a controlled experiment? Did all of the adults sting? Did they all feed? If not, what do they eat? Why would they eat blood? Why is blood a preferred food of some of these insects?

PROBLEM 5. Mosquitoes or pollution - do we have to choose?

Suggested Design:

Set up a series of short term mosquito larvae cultures. Make all conditions standard except the variable which you wish to test. Now from the information gathered in the preceding problem or from information which you can gather in this problem, could you design a mosquito control program for your area? How? Base your answers on experimental results only.

Questions:

a) What method would you use? Draining, spraying, birds or fish?

b) When would you use your method? Spring, summer or fall?

c) How often would you use your method? Every 2 days, every 2 weeks, or constantly?

d) Where would you use your method? On all of the water in the area, on selected water, on land?

e) What would you attempt to control? The eggs, the larvae, the pupae or the adults?

f) What environmental effects would your program have?

g) If spraying is used, would you use a pesticide or herbicide?

Would you use a broad spectrum or a narrow spectrum spray?

h) Is twice as much of a biocide twice as effective? Test this?

WINTER CONSIDERATIONS

Problems 1 to 4 are not suitable for winter projects. Problem 5 could be conducted in winter if mosquito larvae were available. An interesting project would be to collect mud from the edge of an aquatic environment where the water has receded or from the dry bottom of a temporary body of water and to attempt to raise mosquito larvae from this collected mud. Ask your teacher for culturing suggestions.

PROJECTS USING ANTS

GENERAL METHODS:

COLLECTING:

The collecting method used depends upon your reason for collecting the ants. Individual ants can be collected by guiding them into a glass jar. However, if you wish to establish an observation nest then you should attempt to gather as many different castes (queen, worker, etc.) from one colony as possible. One method is to place a spadeful of an ant-dirt mixture on a white newspaper, thereby making it easier to select and capture the different castes. Always try to get a queen. They can be recognized by their large size. Help the remaining ants by repairing any damage resulting from your interference with their home.

CULTURING:

a) Short term (one week). Fill a two quart jar about 3/4 full of the ant-dirt mixture. Substitute a metal top punched full of small air holes for the glass top. Seal tightly. Cover entire glass with an opaque substance like a brown paper bag. Provide food in the form of a few insects put into the cage every day and/or by putting a few drops of molasses or honey on a small sponge or wad of cotton. You may try feeding them any food eaten by humans. Remove any food which has not been eaten in 10 minutes. Provide moisture by either keeping a small wet sponge or a small wad of cotton on the dirt or by sprinkling the top of the dirt with a few drops of water every day. Do not place in direct sunlight. Do not disturb unnecessarily.

b) Long term. Construct a formicarium (Appendix A-10). Provide food and water as suggested in the short term culture method.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. What do ants normally eat?

Suggested Design:

Attempt to find five different ant "homes": under a flat rock, an ant hill in sandy soil, an ant hill in clay soil, in a wood pile, in a building, in a rotten log, etc. Observe and record the kind of food being gathered by at least 20 workers from each different ant home you discovered.

Questions:

Was there only one kind of worker ant in each colony? Were the same kind or worker ants living in different colonies? Was the same kind of food being gathered in each home? If not, did one kind of ant (e.g. red ant) living in one kind of "home", gather one kind of food while another kind of ant (e.g. black) living in another kind of home gather a different kind of food? If so, did this occur by chance or not? You may wish to test this with problem 2.

PROBLEM 2. Do ants have territories?

Suggested Design:

a) Collect 20 worker ants from one ant colony and transport to another similar kind (e.g. both ant hills) and/or to a different kind (e.g. a log) of colony. Release the foreign ants individually and record results.

b) Collect the food being carried by at least 20 worker ants from one colony. Transport the food to another colony (the same kind and/or a different kind) and place the food particles one by one close to this colony. Record the results.

Questions:

Were all of the ants placed at the same distance from the new colony? Were all of the ants placed at the same spot? Did you note ant runways? Did you place some foreign ants in the runways? Did you record the elapsed time between placing and detection? Was there a safe distance from the colony? If foreign ants were recognized, which senses (eyes, ears, smell) were used? If foreign food particles were recognized, which senses were used? What do you think would happen if you removed some ants from a colony, kept and handled them for a few days and then attempted to reintroduce them to their old colony? Would it make a difference if you fed them a different food than that eaten by the mother colony? Try these experiments.

PROBLEM 3. Do ants choose, communicate and recycle?

Suggested Design:

This project can be done in the field or in the laboratory. Select one colony or as many different colonies as are convenient. Provide the ants in each colony with a number of different substances. You may wish to use five ant size pieces of banana peel, crumbs, wood, dead insects, plastic, sugar, plants, honey, dough, vinegar, salt, fat, etc. A Y or T shaped maze may be useful. Record how such substances are handled by recording observations such as: time for detection by first ant, method of detection, method of information transfer to other ants, method of handling, time for removal of all material.

Questions:

Were all pieces the same size? Was the ant's initial reaction the same to all substances? Did they reject some? What happens to the accepted pieces and what happens to the rejected pieces? Could you define pollution on the basis of this experiment? What is the role of the ant in the ecosystem? What is its place in the food web?

WINTER CONSIDERATIONS

Ask your teacher for suggestions for winter projects.

PROJECTS USING WATER MITES

GENERAL METHODS:

COLLECTING:

Water mites may be collected at all seasons. Generally they are more numerous in late summer or early autumn. They may be collected by sweeping a fine meshed dip net (Appendix A-8) among thick growths of aquatic vegetation.

EQUIPMENT:

Dip net, quart jars or plastic bags.

CULTURING:

a) Short term. They may be cultured in a mini-aquarium (Appendix A-4).

b) Long term. The mini-aquarium is still quite adequate. Water mites are generally carnivorous. Since they can live for a long time without food the occasional addition of some small insects, worms or snails should provide adequate energy.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. Do mites living in different habitats exhibit different colorations?

Suggested Design:

Collect water mites from different habitats. See Planaria-problem 1 for suggested habitats. Standard sweeping (e.g. ten 2-meter sweeps per site), accurate counting, identification and recording may provide some answers to the following questions.

Questions:

Did you collect one color mite from only one kind of plant? Did you find the same color of mite on the same kind of plant even in different kinds of water? Did you find different colored mites in the same area? If so, were there always more mites of one color or did predominance of color change in different areas?

PROBLEM 2. Can mites change color?

Suggested Design:

Collect some mites and record the background color of the habitat. Bring the mites to the laboratory and attempt to duplicate this background. Use this background color as your control. Place a set number of mites in different containers and vary the background color of each container.

Questions:

Can you think of some reasons why animals are colored? Why might mites be colored? Could it be to blend with the background to escape predators? Could it be to be conspicuous so as to scare off some would be predators? Did the mites blend with their background? Were they easily seen? Are you a predator? Would another predator likely have the same color vision as you do? What preys on mites? Was the color due to the background? Could it serve a function in courtship display? Could it be due to the food eaten by the mites? Did you test this using food dyed with different vegetable dyes? Do red mites and orange mites live happily together in one container?

PROBLEM 3. How do mites react to population pressure and/or pollution?

Suggested Design:

Place different numbers of mites in the same sized containers with the same amount of water, pebbles and plants. Observe for at least two weeks.

Select a pollutant which may actually enter the water inhabited by the mites; i.e., oil, manure, mosquito killing pesticide, weed spray, etc. Establish a series of test containers all of course containing the same number of mites.

Questions:

Did you have a control? Did you have duplicates? How did you select the amount of a pollutant to be used? Is it realistic? Are mites surface breathers or underwater breathers? How would this affect your results? How might motor boats harm mites? Could you test this using motor boat oil? Can mites move (fly?) from one pond to another to escape a pollutant?

WINTER CONSIDERATIONS

The projects suggested would be difficult to conduct during the winter season.

PROJECTS USING SPIDERS

Most of the spiders found in North America are quite harmless. The black widow spider, found in the southeast portion of the province is the only poisonous one in Alberta. The female black widow spider is about ½ inch in body length, black and shining, with a reddish-orange spot shaped like an hour glass on the underside of the abdomen. The male is smaller and marked the same way. The male is usually killed after mating, therefore it is not seen as often as the female. The black widow spider should be handled only by an experienced person.

GENERAL METHODS:

COLLECTING:

Since spiders are found in a variety of habitats they may be collected in a variety of ways. Generally, it is easiest to collect them by either:

1. locating the webs and individually catching the spiders with a small insect net; or
2. sweeping vegetation with a small sweep net (Appendix A-8), or
3. digging for the burrowing types.

EQUIPMENT:

Appropriate nets and some small plastic bags, spade or trowel.

CULTURING:

a) Short term (for web spinners only). Use can be made of the fact that many spiders cannot travel over water or a polished surface. Therefore stand a potted plant in a bowl of water, or on a polished table. Put two or three sticks or strips of cardboard together, tie them into some sort of polygonal shape and lean this structure against the plant. Put a web spinning spider on the plant and it will probably construct a web. Keep the animal in a cool, rather dark place. Feed it living insects such as flies by placing them on the web.

b) Long term. Spiders which spin webs for the capture of their insect prey may be placed in any well planted terrarium (Appendix A-11). Feed them living insects.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. Where do you find the greatest variety of spiders?

Suggested Design:

Attempt to collect spiders using the sweep method suggested earlier. Firmly grasp the net by the handle and take quick, strong, measured sweeps through the habitat being sampled. Attempt to cover the same area in each sweep. Twist the handle to prevent the spiders from escaping. Empty contents into a plastic bag. Chilling the bag and contents will slow down the spiders allowing you to separate, identify, and to count. Take at least ten sweeps each in three different habitats. For example:

a) a grazed pasture, a stubble field and the edge where the pasture and stubble field meet,

b) ungrazed grass, grazed grass and where the two meet,

c) grass, woods, and where they meet,

d) roadside ditch, stubble and edge,

e) pond shore, 2 feet from shore, 10 feet from shore, etc..

Record the total number of spiders collected per 10 sweeps and the number of different kinds of spiders collected per 10 sweeps. At first simply separate on appearance; i.e., 3 brown, 2 white with black dots, etc.

Questions:

Was your sweeping standard? Which areas had the most spiders? Which had the most kinds? Could you explain why? Is it because of food, shelter, attachment spots for webs, etc.? On the basis of your results could you predict which area may experience a population explosion of spiders?

PROBLEM 2. Does a spider always spin the same kind of web?

Suggested Design:

Collect spiders as in problem 1 being careful not to harm them. Attempt to separate them into different groups. Place one spider of each kind on separate plants as outlined in the short term culturing methods. Record by drawing, photographing, etc. any differences in web construction.

Questions:

How long did it take the spider to construct the web? Is there a difference when using spiders which are in different states of hunger? Is there a difference when the spider is faced with different wind velocities (a fan?), or when faced with persistent sabotage? Have you determined these differences under experimental conditions? What happens if two different spiders spinning two different webs are interrupted in their web building and transferred to each other's web? Do they finish the strange web or start over?

PROBLEM 3. Does a different kind of web catch different kinds of food?

Suggested Design:

Find at least five different kinds of spider webs. Do not disturb the webs. Observe the webs daily for a set period of time (e.g. 15 minutes) for at least a week. Record the number and kind of insects found on each web. Vary the time of observation; i.e. early morning, evening, etc.

Questions:

Did each of the webs catch the same number and the same kinds of insects? Were the insects that were caught harmful or useful to man? Was each of the different webs made by a different kind of spider? Did you see the spider? If not, lure it out to see it. Think of how a spider might detect a prey on the web. A tuning fork may be useful.

PROBLEM 4. How many eggs hatch from one spider cocoon?

Suggested Design:

Collect some spider cocoons. They can generally be found attached to grass or weed-stalks. Place a cocoon in a warm woodland terrarium (Appendix A-11). Record the number of eggs, the number of young that hatch, and the daily number of alive young for at least seven days.

Questions:

Did some young spiders die before and after they hatched? Would this many normally die in nature? Would fewer die? If more, what would kill them? Do other animals eat spiders? What are some of the factors which control the population of spiders? Did you place some cocoons under different conditions of temperature, humidity, or wind to determine possible control mechanisms?

PROBLEM 5. More questions requiring experimental answers.

a) Do all spiders spin their webs in the same way? Do some start in the middle of the web while others start at the edge, for example? Does the same spider build the web in the same way in two different habitats? Do different spiders build their webs in the same way in the same habitat?

b) Is the silk spun by different spiders all the same kind? For example, is some single strand silk and some double strand? Is some sticky and some dry? Does the same spider spin different kinds of silk in the same web? Which ones are often dry and which ones are sticky? Why? Sketch your results or preserve the webs by a method suggested by Fischer[1] (per. comm.). This method involves spraying the spider webs with paint from a spray can and then gently mounting the sprayed web on construction paper. The procedure is as follows:

1. Gently spray the entire web from a distance of about three feet.
2. Place the construction paper behind the web and ease it on to the web. The paper should be large enough to cover the entire web.
3. Carefully break off any strands which are still attached to the trees, etc. before attempting to move the web and paper.
4. Observe and record observations.

Spraying the webs with white paint really helps one to see the outline of the web. It is helpful to study the web at this point, that is, before you place it on the paper. You should record if the web consists of single or double strands or both, which strands have caught the insects, which is the lead strand to the lurking spider, etc. The spider is often caught in the paint or can be located by following strands of the web. If possible, capture the spider alive so that you can match the spider with the web and/or induce the spider to spin another web.

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[1] Dr. R. B. Fischer, Stone Hall, Cornell University, Ithaca, New York.

WINTER CONSIDERATIONS

Problems 1, 2, 3 and 5 are not suitable winter projects unless a supply of spiders and spider webs are available in special environments such as barns or terrariums. In that case, problems 2, 3 and 5 could be suitable winter projects. Problem 4 could be conducted in the winter if spider cocoons are collected in autumn.

PROJECTS USING FRESH WATER SNAILS

GENERAL METHOD:

COLLECTING:

Snails may be collected by hand, with forcepts or with a net. See Appendix A-8.

EQUIPMENT:

Quart sealer or plastic bags, net, garden rake for collecting plants.

CULTURING:

a) Short term (two to four weeks). Keep in the water in which they were collected. A glass container such as a quart sealer is handy for culturing purposes. Place in the container one or two pieces of green plants taken from the water. Place container in moderate light.

b) Long term. Snails may be kept in any aquarium. See Appendix A-4 and A-5.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. Do different habitats have different kinds of snails?

Suggested Design:

a) Attempt to collect snails from different habitats in one body of water (e.g. a pond or dugout). Collect at least two snails of each kind seen. Try habitats such as the weedy side of a dugout, the weedless side, the windward side, the sheltered side, shallow water, deep water, at the shore, two feet from the shore, etc., and/or

b) Collect snails from at least two of the same kind of habitat; for example, from two dugouts, and/or

c) Collect snails from at least two different kinds of habitats; for example, from a slough, a dugout and a creek.

Questions:

Did one body of water have only one kind of snail? If not, how many different kinds did you find? How did you separate the species of snails? You might use the size of the animal, or their color. Which do you think is the best? Why? Did the number of species show any relationship to the number of different habitats you sampled? Did you find certain species of snails associated with certain species of plants? Is variety the spice of life or is it necessary for life? Did all of the snails collected eat the same food? What animals eat snails? What role do snails play in the aquatic ecosystem? Can you compare their role with that of a very common domestic animal? What are the similarities? What are the differences? What happens to the "wastes" that the snails produce? What is the role of calcium in determining where snails live? Is it needed? How? Where does it come from?

PROBLEM 2. What happens to snails in winter and in dry periods?

Suggested Design:

Could you test what happens in either case by using the following materials: snails, pond bottom mud, pond water, waterplants, plastic bags and a refrigerator?

Questions:

How did your laboratory experimental conditions differ from actual field conditions? Were the snails alive or dead at the end of the test? Did you ascertain this? What happens to dead snails in the spring? Do they just disappear? What likely happens to them?

PROBLEM 3. Leeches and/or diving beetles and snails. What is the relationship? Predator, prey or neutral?

Suggested Design:

Place - the same number of snails (e.g. 10) in each of as many sealed pint jars of pond water containing a water plant as are necessary.

Introduce - some leeches and/or diving beetles into each jar. You may wish to keep a constant ratio such as one leech or beetle to two snails. (See the leech project and/or diving beetle project for collecting and culturing methods for those two animals.)

Record - a) the immediate behavior and results. Were the results negative, positive, or was there no evidence of interaction?

b) the behavior and deaths over a two week period.

Questions:

What was the ratio of leeches to snails in the habitat, etc., from which you obtained your samples? What do you think tends to maintain the ratio? If you think it might be the predator-prey relationship then design an experiment to test this. For example, place the ratio of snails to leeches found in nature in a test container. Does the ratio of leeches to snails remain the same?

PROBLEM 4. When does a substance become a pollutant?

Suggested Design:

Place an equal number of snails (e.g. 10) in each of several sealed pint jars of pond water containing a water plant. To as many jars as are needed add one or all of the following and try to use amounts which may actually be entering water in your area:

a) A powdered detergent.

b) A commercial fertilizer.

c) Oil (automobile refined oil) - try 1 drop, 10 drops, etc.

d) Oil - compare automobile oil, crude oil, and any other kind of oil.

e) Pesticide(s) - use amounts recommended, less than amounts recommended, more than amounts recommended.

f) Herbicides - follow the same procedure as with pesticides, compare the toxicity of herbicides and pesticides.

g) A substance used to kill snails - for example copper sulfate (bluestone).

h) Acid or base - test at pH 3 to 11 for example.

i) Any other substance which you know or think might be a pollutant.

CAUTION: Check first to see if it could be dangerous to your own health.

Record:

a) Every 2 days for at least 2 weeks the number of live snails in each jar;

b) Every 2 days the number of trips made by the snails to the surface of the water in a set period of time (e.g. 15 minutes).

Questions:

Were the pollutants you tested and the amounts you tested realistic? That is, does pollution of this kind occur in the world? Support your answers with actual cases. Does this short term test uncover all of the dangers associated with the pollutants tested? Why or why not? What are some of the other dangers? Can you design an experiment to test these other dangers? Were your test conditions standard? How might the elimination of a snail population affect a pond? What suffers? What is helped? To help you speculate look at a textbook description of a pond ecosystem. What is the connection between snails, birds, fish, swimmer's itch and humans?

WINTER CONSIDERATIONS

Problems 1 and 3 would probably be best suited to seasons other than winter. Problems 2 and 4 could be conducted during any season. A winter field research could be conducted to determine the answer to problem 2 and problem 4 could be conducted with snails cultured in aquaria for this purpose.

A winter project using snails could be to determine if different parts of a body of water contain different numbers of snails and if so to attempt to propose some reasons why this might be the case. For example, one could collect measured amounts of frozen mud (use an axe or an ice pick) from different parts of a slough, i.e., weedy portion, weedless portion, sand bottom, clay bottom, etc. The mud could be taken to the laboratory where the number of snails could be counted. Counting could be aided by the addition of slough water, distilled water or aged tap water to the mud. This mixture should then be cultured for at least two weeks so that changes in the number of snails and in their behaviour could be recorded.

PROJECTS USING FISH

GENERAL METHODS:

CAUTION: Do not move fish from one body of water to another. If you do, you may be introducing a new species into a new habitat. The introduction of the rabbit into Australia or the starling into North America should alert you to the danger involved in such a foreign introduction.

COLLECTING: (Small fish)

Small fish, such as shiners, dace, minnows, suckers, and sticklebacks, may be collected using a dip net (Appendix A-8). If you wish to keep them alive, handle them only with wet hands and bring to the laboratory from the field in large containers with plenty of water. Pails or large plastic bags are recommended. Attempt to avoid a great increase in water temperature when transporting fish from the field to the laboratory. For long distance transportation you may wish to put the fish in plastic bags in a picnic cooler and perhaps add some ice. Keep the temperature just above freezing and in the laboratory allow the water to warm slowly to the temperature of the laboratory container; i.e. aquarium.

EQUIPMENT:

Net, pail, plastic bags, thermometer, picnic cooler, ice if necessary.

CULTURING:

a) Short term (1 - 2 weeks). They may be kept in any glass or plastic container filled with well oxygenated natural or aged tap water. Oxygen may be provided by aeration, photosynthesis, or by replacing ½ of the old water with fresh well oxygenated water every 24 hours.

b) Long term. A "balanced" aquarium (Appendix A-5) is the best. A screen should be provided to prevent the departure of inhabitants. Attempt to determine the preferred food and collect this while you are collecting the fish. Try feeding the fish live food such as aquatic worms and various pond crustaceans. Do not overcrowd. A good rule to follow is one gram of fish per one liter of water.

SUGGESTED PROCEDURES:

Select one, any number or all of the following as a project.

PROBLEM 1. Are small fish all of the same kind?

Suggested Design:

Select a body or bodies of water where you suspect the presence of fish. Collect from as many different habitats as you can find. Keep collected fish in separate containers. Compare size, color, body shape, shape of mouth, number of fins, position of the fins, and the form of the fins.

Questions:

How many different kinds of fish did you collect? Did you collect more than one kind from the same area? If so, how do you think they can live together? Do they eat the same food? Do they react in the same way to light? Were some territorial? If so, how did they defend their territory? What happened to those that were unable to secure a territory? Literature research or more experiments should provide some answers to these questions.

PROBLEM 2. What are some effects of pollution on fish?

Suggested Design:

Place a set number (2 to 5 depending on size) of small fish in test containers (e.g. quart jars) of well aerated aquarium water. Place pollutants at different concentrations in different containers remembering to keep one container as a control. Unless you are testing for lack of oxygen, insure an adequate supply of oxygen. Try to select pollutants and concentrations which are actually entering water inhabited by fish. Do not feed the fish during the test period of four days. You may wish to test five different concentrations of each of the following:

a) Organic pollution; mixed sewage (full strength and four dilutions), fertilizers, phosphates, etc.

b) Toxic pollutants; salt, chlorine (household bleach), copper (copper sulphate - "bluestone"), zinc, pesticides, herbicides, oil (crude, refined, etc.), etc.

c) Inert pollutants; silt, coal, etc.

You may also wish to determine the effect of certain conditions such as:

a) Different concentrations of oxygen (Appendix A-1).

b) Temperature changes.

  i) Find the maximum tolerated temperature, and/or

  ii) Find some effects of changing temperatures.

c) Varying the number of fish per container. Try 5, 10, 20, etc., per one quart container. Record behavior, deaths, and change in total weight. Observe for at least two weeks.

Questions:

Were the test fish all the same size? Were they the same species? If not, how might this influence results? Does the four day test provide a complete picture regarding a pollutant? What might be the effect if the same pollutant at the same concentration is tried on fish eggs and adults? What might be the effect if the same pollutant is tested at different temperatures or at different oxygen concentrations? Do all of the pollutants act directly on the fish? If not, how do they act? For example, in what ways could pesticides, sewage or silt indirectly affect fish survival in a stream? What might be the effect of two or more pollutants mixed together? Would it be the same as adding the effect of each by itself? What would be the effect of two or more pollutants mixed together under different conditions of temperature or oxygen? Literature research might provide some answers to the questions raised.

WINTER CONSIDERATIONS

The projects outlined could be conducted during any season.

PROJECTS USING FROGS AND TOADS

GENERAL METHODS:

COLLECTING:

a) Eggs. The shape and size of eggs vary with the species of frog or toad. Initially you should look for clusters or loose masses of eggs just below the surface of the water or floating on the surface of the water. Place the eggs in a container of water from the body of water under study. Early spring is, of course, the best collecting time.

b) Tadpoles. Tadpoles may be collected with a dip net (Appendix A-8) and kept in the water in which they were collected. In Alberta these can most easily be collected during summer months.

c) Adults. Careful daytime stalking may be utilized. However, nighttime stalking with the help of a flashlight may be more rewarding.

CULTURING:

a) Eggs. Clumps or masses of eggs could be placed in an aquarium which does not contain predators. It would be advisable to have only sand, water and fresh green aquatic plants. Do not let the eggs touch the sand. Do not overcrowd the container. Attempt to limit the eggs to a single layer covering one-half of the bottom of the container. Remove dead eggs (white ones) daily.

Alternatively, any clean glass container (e.g. pint jar) containing fresh aerated water may be used. An alternative to aerating may be to change one-half of the water daily with fresh water from a pond or stream. Watch the temperature of the water. DO NOT place in direct sunlight.

b) Tadpoles. Being herbivorous, they require a fairly large, algae-rich aquarium (Appendix A-5) with few or no predators. Boiled lettuce may be substituted if algae are not available. Water should be changed about three times a week.

c) Adults. A few specimens (about four) can be kept quite well in a woodland or semi-aquatic aquarium. Attempt to duplicate natural conditions for your type of frog or toad as much as possible. Attempt to feed living insects such as mealworms, flies, small grasshoppers, etc. Beef liver may be accepted if waved before them on the end of something like a toothpick or broom straw.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. Millions of eggs - hundreds of frogs - why?

Suggested Design:

Attempt to collect eggs from as many different habitats as you can find. You may wish to try ponds of different sizes, roadside ditch, stream, lake, hollow tree stump, etc. Record the estimated abundance of eggs (e.g. 100 per cubic foot of water) and the estimated abundance of adult frogs. You may wish to increase the accuracy of counting the adults by establishing a study area, capturing adults, marking, releasing and attempting to recapture (Appendix A-9).

Questions:

What percent of the eggs become frogs? What happens to the others? How does the percent survival compare with mammals? Is there a possible connection between parental behavior and the number of eggs laid per female? What could be some of the direct causes of mortality of the eggs, the tadpoles, and the adults? The next problem may be one method for determining this for the eggs.

PROBLEM 2. What could limit the number of eggs which hatch?

Suggested Design:

Collect as many eggs as are needed. If possible, record the relative abundance of the eggs and the temperature, pH and oxygen content (Appendix A-1, A-6) of the water. In the laboratory divide the eggs into groups of 10 per container. A pint jar may be a handy test container. Determine the possible effect of all or any of the following by recording the time to hatching and the number of live tadpoles produced in each container.

a) Temperature. Try 30, 40, and 80 degrees F., or, try freezing, cool (refrigerator), room temperature, in direct sunlight, and a container suspended in the body of water from which you collected the eggs.

b) Oxygen. Vary from 0 p.p.m. (mg./liter) to 10 p.p.m. You could try controlled aeration. However, this is rather difficult. Through trial and error you may be able to achieve a stable level of oxygen content by using different size polyethylene sour cream bags

(Appendix A-12) in jars containing the same amount of photosynthesizing plants. Be careful how you obtain the water sample for determination of oxygen content. A rubber hose or pipette may be helpful.

c) pH. Vary from 5 to 11 (Ask your teacher regarding the use of buffers).

d) Smothering. Sprinkle periodically (every two days) different measured amounts of sand over eggs in different containers.

e) Lack of moisture. Example: no water, eggs on piece of floating wood, eggs in water.

f) Infertile eggs. Raise under ideal conditions and note number that do not hatch.

g) Space available. Vary the number of eggs per container: 10, 30, etc.

h) Predation. Collect possible predators from the pond and either place one type of predator in different numbers in all containers or place a set number of different predators in each container.

i) Pollution. Try to use actual pollutants which may be entering water where frogs and toads are found. Vary the amounts of these pollutants. For example; oil - 1 drop, 2 drops, etc.; a pesticide used for mosquito control at recommended dosage, less and more than recommended dosage; fertilizers. A good pollutant to try would be salt. In many areas salt from roads would be entering roadside ditches in early spring when frog eggs are hatching.

Questions:

Did you have control containers for all of your experiments?

Did you control all other variables except the one you were testing? If not, did you recognize and record other variables? Did you try to see how a combination of these factors may affect mortality? For example, what happens if you have a high temperature and then introduce predators? Is there more predation at higher temperatures than at normal temperatures? Did you attempt a field study to determine if the conditions which were reducing the hatchability of the eggs in the laboratory, occur in the field?

PROBLEM 3. How are tadpoles and frogs adapted to their environment?

Suggested Design:

Collect or raise some tadpoles and some adult frogs. Record observed and measured anatomical, physiological and behavioral differences between tadpoles and frogs. For example, what are the differences in: method of breathing, method of feeding, food eaten, method of moving, length of limbs, type of eyes, length of tongue, color of skin, etc.

Relate differences to difference in habitat.

Questions:

Could you design some experiments to determine if the measured or observed phenomena are necessary for the survival of the amphibian at the life stage studied? For example, what happens when you attempt to feed a frog herbaceous material?

PROBLEM 4. Why do frogs croak?

Suggested Design:

Select an area where frogs may be found such as a pond, slough, or roadside ditch. Define a study area. At one week intervals starting after the ice melts, attempt to:

Collect frogs' eggs, listen to or record the sound and volume of the frog "chorus." At the same time do any or all of the following:

a) catch and attempt to identify a male and a female frog from your study area. If you cannot identify at least record the size, appearance, and color so that you can determine if you have more than one species in your study area.

b) catch and keep in a terrarium (Appendix A-11) two males and two females. Males, especially during breeding season, sometimes have larger thumbs than females. The looseness of skin around the neck region and the release of eggs when stroking the body may help you distinguish males from females.

Questions:

Did you have only one kind of frog in your area? How many different frog "songs" did you note? If you had more than one species did the different species croak on the same night? What do you think is the purpose of croaking in frogs? How do they make the sound? Do both sexes croak? Did you find any correlation between the croaking and the appearance of eggs in the water? Did the frogs in the terrarium "sing"? Did they lay eggs?

PROBLEM 5. More questions with suggested designs.

a) Is a frog a habitat?

Collect one, or preferably more than one fresh, adult frog. Hunt for animals living on this frog. Then double pith the frog and hunt for internal parasites. For example, cut the lungs free at the head end and place in bowls or cups of saline solution (0.7 gm. of sodium chloride - table salt, in 100 ml. of water). Pull the tissue apart. Record your observations. You may also wish to look in the urinary bladder and the abdominal cavity.

b) Do frogs change color according to their surroundings?

Place frogs under different light, humidity and background color conditions. Leave for at least two weeks. A camera may be useful to get an accurate pre- and post- test record.

c) Does a frog's body temperature change with changes in air temperature?

i) Subject frogs to different temperatures. Measure the air temperature and the frog's body temperature (in mouth or cloaca) immediately after placing it in the new temperature, ½ hour after, 2 hours after and 24 hours after.

ii) Take a frog from one temperature and place it in an area where it can choose between the old temperature and the new one. What choice does it make?

WINTER CONSIDERATIONS

Problems 1, 2, 3 and 4 are all problems best conducted in spring. Problem 5 could be conducted any time adult frogs are available.

PROJECTS USING HOUSE SPARROWS AND COMMON STARLINGS

It may be mentioned that the House Sparrow (*Passer domesticus*) and the Common or European Starling (*Sturnus vulgaris*) are not included in the list of birds protected in Canada under the Migratory Birds Convention Act. The House Sparrow (or English Sparrow) was introduced into America in 1850 by well meaning persons who thought it would be valuable as an insect destroyer. About 40 years later several pairs of Common Starlings were brought from Europe and liberated in Central Park, New York City.

SUGGESTED PROJECTS:

Select all, or any part of the following problem as a project.

PROBLEM 1. Why are these birds so common and successful?

A. Literature research.

- a) Trace the spread of both of these birds over temperate North America.
- b) Attempt to discover what native birds have been displaced because of these intruders and why they have been displaced.

B. Field research.

- a) Attempt to discover and explain why these species have been so successful in propagating their own kind.
- b) Attempt to determine the success of various control methods tried.

SUGGESTED DESIGN for B-a

Select a study area and attempt to work out the life history of either the sparrow or the starling. For example, you may wish to: determine the total population of birds in your study area, the number of adults in your study area, the number of breeding pairs in your study area, the type of nest, the number of nests, the location of the nests, the number of hatching young per nest, the number of surviving young leaving the nest, the number of surviving adults per nest (band or mark the young in the observation nests), the food eaten at various life stages. (You may wish to determine nestling food by placing a pipe cleaner around the neck of the young so as to prevent it from swallowing the food brought by the parents. A syringe or forceps may be used to remove the food from the birds' throat. Killing birds of the same age from another nest and opening the gizzard and crop may be another method.) Watch the behavior of the study birds when faced with intruding birds of the same species (both male and female) and/or when intruding or being intruded upon by birds of different species (both sexes), etc.

SUGGESTED DESIGN for B-b

Select a study area and a method of controlling the birds, e.g., preventive, frightening or destructive. Select the object of control, e.g. nest, adult bird, etc. and determine its abundance in your study area. For example, count the number of nests in the study area if you wish to use nest destruction as a control measure. Carry out the control measures either daily, weekly, or every two weeks. Determine the effectiveness of the measures on the day when you stop the measures and after a lapse of 2 weeks. You may wish to try:

1. Preventive measures. For example, eliminate food attractions (garbage, poultry feed, etc.), or block nest and/or roosting sites, or trim roosting branches from trees, or eliminate shelter sites, etc.
2. Frightening measures. For example, shake trees to chase away adults, or shine lights on roosting sites, or construct a noise making apparatus, etc.
3. Destructive measures. For example, shoot adults, destroy nests, destroy eggs, live trap and remove from the study area, trap and destroy, etc.

Questions:

Did you have a control study area? Did you determine the length of time it takes for an egg to hatch? Did you determine the time from hatching to adult egg-laying bird? Did you compare these times to native birds which may have been eliminated from the area? Do the intruders have an advantage? Did you compare the number of young surviving per nest with those of native birds? Did you compare the size or brood with that of native birds? Did you establish artificial nesting or brooding sites to determine the time for invasion by intruders or competitive native birds? Was your method of control successful? Did it totally and finally eliminate these birds from your study area or was it just a temporary measure? Did it remove only the study birds? From your observations would you recommend the bounty system (either

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for eggs or legs) to help control these birds? Why or why not? Would you recommend introduction to North America of a predator from the bird's native land? Why or why not? Many of the above questions might be answered through literature research.

WINTER CONSIDERATIONS

The problem suggested covers a wide range of research topics some of which are suitable for winter. For example, the literature research suggested in Problem 1A could be conducted during winter. The suggested design for B-a also could be modified into a very interesting study centered on a bird feeder. As a suggested design for B-a you might: "determine the population of birds in your study area . . . and watch the behavior of the study birds when faced with intruding birds of the same species (both female and male) and/or when intruding or being intruded upon by birds of different species (both sexes), etc.". The bird feeder could be the center of your study area and the different species of birds, i.e. chickadees, grosbeaks, etc. coming to feed at the feeder would be study animals. The behavior of the birds should be observed daily for set times (e.g. 15 to 30 minutes per day) for at least one to two weeks. Accurate and detailed records are absolutely necessary for this kind of study.

Another associated winter project could be to conduct a winter census of resident birds to attempt to determine which birds are winter residents and how they adapt to the winter climate. Observations regarding food habits, type of shelters used, and changes in plumage could be made. A background literature research study might help in the design of such a project.

PROJECTS USING BREEDING BIRD POPULATIONS

(BLACKBIRDS, ETC.)

NOTE:

The Canada Migratory Bird Regulations state "No person shall take, injure, or destroy the eggs or nests of migratory birds at any time." When doing this project, please observe only from a distance. Please do not touch or disturb nests, eggs or adults in any manner.

PROBLEM 1. To determine choice breeding sites and the behavior of breeding bird populations.

Suggested Design

Select a study area. Determine the size (an area 209 x 209 feet is approximately one acre). Draw a map of the area noting plant community types. Note location of nesting sites; the number of eggs in the nest; the estimated total number of birds of the species under study; the number of breeding pairs in the area; the number of male birds in the area; and the behavior of the study birds; i.e., singing, feeding, courtship activity, nesting behavior, strife within the species, strife with other species, etc.

Questions:

How many times did you visit the area? For how many weeks? Was there any evidence of a preferred habitat in the species under study? What was the ratio of males to females in the area? Were there extra males or females in the area? If so, did they seem to have well-established territories? If territories were well established how were they defended? How do you think birds of the same species or birds of other species recognize the existence of a territory? Were all of the nests in the same type of habitat (e.g., cattail marsh)? Were all the nests at the same height? If not, do you think one habitat was a prime nesting area while another was a second choice? If so, what makes one better than the other? Could it be the amount of available shelter, the nearness to food, the access to water, the access to nesting material, etc.? If nests were found in different habitats and if the birds were territorial, were the territories in the better habitat smaller, larger or the same size as those in the poorer habitats?

PROBLEM 2. To demonstrate territorial behavior in red-winged blackbirds.

Suggested Design

Select a study area containing at least one male red-winged blackbird (*Agelaius phoeniceus*). The males are the ones displaying their scarlet epaulettes (red shoulder patches) and singing. Note the angle of the beak and neck and the location and size of the red shoulder patches. If possible, record the singing of the study male, a neighboring male and a stranger male, i.e., from a different marsh, on a tape recorder. Visit the area in the evening and note and mark the spot where the study bird was seen singing on a perch. Attempt to select spots close to a road so that you can later observe the bird without disturbing it.

Construct a dummy bird. The dummy should resemble the real bird as much as possible, however, the important parts are the beak, the neck and the red shoulder patches. Try to duplicate the angle of the beak and neck and the size, location, color and prominence of the shoulder patches.

Next evening place the dummy on the spot where the real bird was seen to be singing. Move away from the area, observe for at least fifteen minutes and record the reaction. If the singing was recorded on tape then note if there are different reactions if you:

1. Place only the dummy on the perch, or
2. Place only the tape recorder on the perch and play-back the singing of a neighbor bird or a stranger bird, i.e., from a different marsh area,
3. Place the dummy and the tape recorder on the perch and play-back the singing from a neighboring bird or from a stranger bird.

Questions:

How many times was the experiment repeated? How many different male blackbirds were involved in the experiment? What would happen if you recorded the song from one bird and played it back to the same bird the next evening with and without the dummy? Did you try this? If territories were well established how were they defended? How do you think birds of the same species or birds of other species recognize the existence of a territory? How does the establishment of a territory help to control the population of blackbirds?

WINTER CONSIDERATIONS

The projects must be done in the spring during breeding season, therefore, they are not suitable for winter.

PROJECTS USING WATERFOWL

NOTE:

Most waterfowl are protected birds. Therefore, except for allowable hunting do not disturb them in any manner.

PROBLEM 1. To determine the preferred habitat of various waterfowl.

Suggested Design:

Select either:

a) one water habitat as your study area, and/or

b) a number of similar habitats (e.g., cattail sloughs) of different sizes, and/or

c) a number of habitats of different types (e.g., slough, creek, lake, dugout, marsh, etc.) making the study area the same size in each type.

Determine by observing for ½ hour in the morning and ½ hour in the evening (dawn and dusk?) the:

a) approximate number of waterfowl per study area, and/or,

b) the dominant species of waterfowl (e.g., mallard, pintail, Canada goose, etc.), and/or, the approximate number of each species, and/or,

c) the feeding behavior of each species.

Questions:

What type of habitat had the greatest number of waterfowl? Which had the greatest variety of waterfowl? Which had the greatest variation in habitat? Which had the greatest number of ecological niches? Did you find a correlation between the kind of water body and the kind of waterfowl? Did all species feed in the same manner? If not, how would different feeding behavior allow for greater use of available food? Did you, for example, see surface feeders, deep divers, shore feeders, etc.? How might one type of feeding help the other type of feeder? What are some anatomical adaptations for the type of feeding: beaks, shape of body, feet, wings, length of neck, location of eyes, etc.? Did all species feed at the same time? If not, how would this help sustain more waterfowl? How did each kind of bird take off from the water - running start, flying start?

WINTER CONSIDERATIONS

The complete project as outlined is not suitable for winter. However, it could easily be adapted to a study which would attempt to determine the habitat and behavior of various overwintering waterfowl. A suggested design for this type of study would be to:

(a) Select one open water habitat as your study area, and

(b) Determine by observing daily for a set time (e.g. 1/2 hour) the approximate number of waterfowl per study area, the dominant species of waterfowl, the approximate number of each species, and the feeding behavior of each species.

Most of the questions in the "question" section of this project would be applicable to this type of winter study. A pair of binoculars and a field record book would be necessary for a study this nature. Recording field data while observing birds in winter is quite difficult, therefore, it is suggested that the project should be conducted together with a partner.

PROJECTS USING PHEASANTS AND GROUSE

SUGGESTED DESIGN:

PROBLEM 1. What are some factors that determine the number of pheasants in an area?

Suggested Design:

The technique suggested is based on the habit of territorial cock pheasants of crowing at approximately 2-minute intervals during the early morning hours on clear, calm, spring days. In flat terrain, with medium to light cover, crowing pheasants may be heard for a radius of about 3/4 of a mile which gives an area of approximately 2 square miles. Therefore, set up listening stations 1 mile apart. Listen and record at each station. This should give you the crowing index (average number of crowing cocks per 2 minute stop). Attempt to correlate crowing index with suitable habitat available to pheasants. For example, record the percentage of trees, bush, roadside ditches, cultivated land, summerfallow, etc., in either a radius of ½ mile or in a 2 square mile area.

Questions:

How many stations are needed to give a good estimate of numbers? How many times should you visit the same station? Did you find out why there are more cock pheasants in one area than in another? Did you find a correlation between type of habitat and number of cock pheasants? What do you think the total population of pheasants is in the area surveyed? Could you find the sex ratio of males to females by personal observations, by talking to hunters or wildlife officers or from the literature? What does the term "territorial cock pheasant" mean? What is the size of the territory? How does this affect total population? How do hunters affect the total population? Did you support your answer with facts? Can you correlate the previous winter's weather with the number of cock pheasants heard in your area? How does this affect the total population?

PROBLEM 2. What is the connection between "drumming" and the grouse population?

Suggested Design:

The technique is based on the habit of ruffed grouse to drum at approximately 4-minute intervals during the early morning hours of clear, calm spring days. Drumming does not carry as well as the crowing of cock pheasants; therefore, listening stations should be established at 1/2 mile intervals. The method used for establishing stations is the same as that outlined for the pheasants (problem 1). However, the direction of sound should be recorded as well as the drumming index (average number of drummings per 4 minute stop). If the direction of the sound is recorded at two adjacent listening stations one can draw a triangle to locate the drumming log. The two listening stations are the corner points on the base of the triangle and the extension of the sides until they meet pinpoints the third point of the triangle, i.e., the drumming log. Location of the drumming log allows for many additional projects.

Questions:

Why do grouse drum? Where do they drum? Can they drum anywhere? What makes a drumming area unique? What time of day does most drumming take place? How many males were heard in your study area? How many males were observed at each drumming log? What was the size and position of the drumming log? How many droppings (per square meter) were found in the area? Where were most of the droppings located? What kind of vegetation surrounded the log? What was the size of the vegetation? How is the drumming sound produced? Does a male have only one drumming log? What happens to the fall grouse population when the drumming area is destroyed? Can you support your answer with facts obtained through literature research? Did you relate the number of grouse to the habitat available? How? Based on your field observations, how would you suggest the grouse population might be increased in your study area?

WINTER CONSIDERATIONS

The projects outlined are spring projects. However, one of the questions asked in the pheasant problem is: "Can you correlate the previous winter's weather with the number of cock pheasants (or grouse) in your area?" This question can lead to other questions and possibly to winter projects. For example: What do the pheasants and/or the different species of grouse feed on in your area? Where is the food located? Is it located in an open field, in bush, close to a feedlot, etc.? Do the birds fly great distances from their shelter to food or is the food and shelter located in the same area? How do these birds keep warm? Do some use snow as a shelter and if so, how?

Do you have photographic evidence of the use of snow for sheltering purposes?

PROJECTS USING BEAVERS

PROBLEM 1. How do beavers change an ecosystem?

Suggested Design:

Locate a beaver dam or evidence of present or past beaver activity. Measure an area around this evidence for your study area. For example, if you are studying bank dwelling beavers, you may wish to measure a strip 100 x 20 feet on each bank. Select an area of similar size that does not show any evidence of beaver activity.

Determine:

1. The number, circumference, height, and kind of trees in both areas (e.g. 10 poplars over 12 inches when measured two feet from ground level), and,
2. The percent of open area in each plot, and,
3. The percent of ground covered with grass in each plot.

Questions:

Did the beavers cut only certain trees of a particular size? Did they cut all trees in the area? If so, what happened to the beavers? Did they move down the stream? Did they move further back into the woods and further up or down stream for their wood? Did they eat themselves out of house and home? Are beavers a help or a hindrance in matters of flood control and water conservation? Do you have field evidence for your answer? Do beavers provide for or destroy the habitats of other animals? If both, which animals benefit, which suffer?

WINTER CONSIDERATIONS

Please ask your teacher regarding winter projects using beavers. Note weak ice covering winter food store. Do not fall through.

PROJECTS USING SMALL MAMMALS (DEERMICE, VOLES, ETC.)

GENERAL METHODS:

COLLECTING:

These small mammals may be collected using a variety of methods. The best method for the purpose of these projects would be some form of live trap (Appendix A-14). The animal would then be caught alive and unharmed and could be returned to the field alive and unharmed after the project has been completed. If dead animals are desired a form of snap trap (Appendix A-15) will kill the animal quickly and humanely.

CULTURING:

A variety of homemade and commercial cages may be used to house small mammals (Appendix A-16). Whichever is used it is very important to feed the animals and to clean the cages daily. Fresh water should be available at all times. Some type of nesting material should also be available. Do not overcrowd cages. One square foot per pair of mice is a good average size. A basic diet of mouse pellets or lab chow supplemented with a variety of other foods such as apples, raisins, sunflower seeds, dried bread, rolled oats, cookies, and green grass appears to be suitable. Extra food and water should be provided if cages cannot be visited on a daily basis.

SUGGESTED PROJECTS:

Select one, all or a number of the following as a project.

Possible Methods to be used for problems one to four.

You may wish to seek answers to problems one to four by using one or all of the following three standard small mammal population census techniques. You should of course, modify the basic technique to suit the problem, the equipment available, and the time available.

1. Live trapping.

Twenty-five trapping stations, of three traps each, should be set at 42 foot intervals. A straight line or grid pattern may be used. A 25 station grid with a 42 foot interval will sample approximately one acre. Traps should be checked at 12 hour intervals, and each mammal should be removed, marked (human hair dye or a water proof felt pen) and released at or near the point of capture after you have recorded species, sex, length and/or weight. Traps should be left in the same spot for three 24 hour period of trapping, then taken up and the total catch tabulated. Bait consisting of a mixture of peanut butter, rolled oats, and bacon grease smeared on the trap pedal could be used. Some nesting material (cotton or terylene) and some food should be placed in the traps.

2. Snap trapping.

The same procedure as for live traps except traps may be checked at 24 hour intervals. Nesting material is not required. Sprung traps should be reset and all mammals taken to the laboratory for study.

3. Scat boards.

These are small boards, four inches by four inches, cut from ¼ inch three ply exterior grade plywood. Small mammals will often use these smooth flat surfaces for defecation sites, and thus leave a sign of their presence. A similar pattern can be used as for live trapping. At least 100 boards should be used, and should be visited every 24 hours. All used boards should be brushed or wiped clean with a cloth and put back in place. All boards should be left in place for at least three consecutive 24-hour days. You will of course, have to determine the type and if possible, the amount of scat produced by each type of small mammal in your area. Live trapping may be helpful.

PROBLEM 1. Where do small mammals live?

Suggested Design:

Try to catch and identify some small mammals in a number of different habitats. You may wish to sample:

a) In some trees, in the grass next to the trees, and along the edge where the trees and grass meet;

b) From the shore of a water body to the climax ecosystem (in some places this may provide at least five sampling stations - shore, grass, shrubs, deciduous trees, and coniferous trees);

c) In tall grass, in medium tall grass, and in short grass;

d) In a newly disturbed area, in an area disturbed one or two years ago and in an undisturbed area;

e) In overgrazed pasture, in grazed pasture, and in non-grazed pasture;

f) In a pine dominated forest, in a spruce dominated forest, and in a poplar dominated forest;

g) In and around a granary, etc.

Questions:

Did you set the traps or boards randomly or did you select areas such as runways where you suspected the presence of small mammals? Did you bait the traps or boards? With what did you bait your traps or boards? What would be the advantage and disadvantage of select site trapping and baiting? How might this affect the results?

Did you find a favored habitat for each species trapped or noted? Did you find one kind of small mammal limited to one type of habitat? Did you find one kind of small mammal appearing to prefer one type of habitat? If so, why might this be? Might they choose the area because of the availability of food, the presence of shelter, the lack of predators, the "softness" or type of soil, etc.? Did you find a mixture of species in places where two ecosystems meet?

Did you note anatomical features which would be most suited to a particular type of habitat? For example, could you relate the advantages or disadvantages to the animal in having a short tail, long ears, fat body, long vibrassae, etc., to the habitat in which it tends to live?

PROBLEM 2. How many small mammals per study area?

Suggested Design:

Select two study areas. Using any or all of the methods suggested above, attempt to obtain an estimate of the relative number of small mammals in each area.

Questions:

Did you attempt to control possible variables? For example, did you set and check the traps at the same time of day? Did you use the same kind of traps, set in the same pattern, using no bait or the same kind of bait in each study area? If you found more small mammals in one area than in the other, what could be the reason? Were the same species present in the same proportion in each area?

PROBLEM 3. How far does a small mammal wander from its home?

Suggested Design:

Select one or a number of study areas. Place a number of scat boards in a grid pattern. Place a non-toxic dye, such as Fast Green FCF, Methylene Blue, Fluorescin or Orange 1, on bait such as rolled oats or a mixture of rolled oats and peanut butter mixed with bacon grease. Then depending on the number of scat boards and the size of the study area either:

a) Place the dyed bait in the center of the grid or at various chosen spots, and/or,

b) Feed one small mammal the dyed bait and release it in the middle of the grid.

By using different colored bait in different parts of one habitat or in two closely associated habitats (e.g. two granaries) and by recording the color of the scats, you should be able to determine the range of movement of an individual or a group of individuals.

Questions:

Did you determine the home range of all small mammals in your study area or of only one species? How might your choice of bait influence this? Did you correlate the range of movement with the habitat; i.e., if animals moved further in one area than in another why might this have happened? Was it because of food or water? Were they trying to extend their territory? Were they trying to escape from predators? What limited the movements of the animals? Were there physical barriers like rivers? Were there biological barriers such as another population of mammals?

PROBLEM 4. When are small mammals active?

Suggested Design:

a) Field Studies. Select a study area or a number of study areas. Use any of the three suggested methods, but, check your traps or scat boards every 2 hours for a period of 24 hours. Record the number and type of mammal caught or the type and amount of scat observed per 2-hour period. A less accurate version would be to visit the traps or scat boards twice in 24 hours, morning and evening.

b) Laboratory Studies. Obtain one or two small mammals. Allow them to get used to the laboratory environment before starting the test. Then either:

i) Attempt to observe without disturbing when they are most active in the 24-hour day.

ii) Record the amount of droppings at various periods of the 24-hour day.

iii) Place a smoked kymograph paper on the floor of the cage and replace paper at various times of the 24-hour day.

iv) If available, use an activity (exercise) wheel.

Questions:

Were all of the small mammals most active at the same time of day or night? If not, did you determine when each species was the most active? Did you discover any reasons for peaks of activity? Did you find an activity rhythm in the 24-hour day? Was it different for newly captured mammals as opposed to laboratory acclimated animals? If a rhythm exists, can it be changed? For example, what happens if you vary the daylight hours or keep the animals under constant light?

PROBLEM 5. Winter questions requiring experimental answers.

Where do small mammals in your area spend the winter? Do they hibernate? If not, what do they eat? How do they keep warm? What is the temperature where they feed and sleep? Is it as cold as the temperature of the air? If not, what is the difference in temperature? Can you trap small mammals in winter?

WINTER CONSIDERATIONS

Problem 5 provides some questions which could lead to winter projects. Please ask your teacher for possible design suggestions for these projects.

PROJECTS USING POCKET GOPHERS

True moles are not present in Alberta. The rodent often mistakenly called a mole is a pocket gopher.

GENERAL METHODS:

COLLECTING:

Pocket gophers are classified as pests and as such may be collected in any manner desired by the collector. Since they are burrowing rodents, seldom seen above ground, live collecting presents a problem. Live traps (Appendix A-17) may, however, be placed in either the feeding or the living tunnel. The following method, modified from that suggested by the Alberta Department of Agriculture, may be used.

1. Locate the newest mound in an area.
2. Probe with sharp object or rod to locate the main runway.
3. Dig down at a distance of about 2 to 3 feet from the new mound, until you locate the runway. Remove soil from the burrows so that traps can be placed far back into the tunnels.
4. Fasten trap to a piece of wire and attach other end of wire firmly to a metal stake to serve as an anchor.
5. Set and place two traps, one in each direction.
6. Open burrows attract the gopher and it should be caught while trying to plug them. Do not let in any light or it may spring the trap by pushing a large amount of soil ahead

of it. Completely cover the entrance with pieces of sod.

CULTURING:

A covered ground squirrel cage (Appendix A-18) ½ full of moist soil could be used. Any kind of vegetable, especially roots (carrots, beets, etc.) could be used for feed.

PROBLEM 1. How many pocket gophers make all those earth mounds?

Suggested Design:

Select a 1-acre study area, which contains evidence of gopher activities. Count the number of burrows in this area. Set traps in the fresh burrows. If live trapping, mark captured animals (try human hair dye or a waterproof felt pen).

Questions:

When did you set and check the traps? Morning or evening? Did you trap during mating or breeding season (May-June)? Would you expect more or fewer gophers in your study area during mating season? Did you test this? What was the territory size of each gopher? How many mounds per gopher per season? Did you find more than one kind of tunnel; i.e., more than one level? Why do you think this area was chosen by the gopher? Was it the type of vegetation, the type of soil, the lack of predators, the lack of disturbance, or just chance?

PROBLEM 2. How are pocket gophers specialized for underground living?

Suggested Design:

Capture one, alive if possible. Compare with a ground squirrel and if possible with a tree squirrel.

Questions:

Compare the digging adaptations - For example, shape of head; length and curvature of incisor teeth; shape, length and number of claws; body shape; location of eyes; size of eyes; length of ears; thickness of fur over entire body and over specialized areas such as the tail; length and shape of tail, musculature of limbs, etc. Why are they called pocket gophers? Where are the pockets? What are they used for?

PROBLEM 3. More questions requiring experimental answers.

a) What factors control the number of pocket gophers in a 1-acre area? What controls the total number of pocket gophers in a province? Is it the same mechanism?

b) Are pocket gophers harmful to man? Do they help man in any way?

c) How many young are born per female? How many litters are born per year? How many survive to adults? You may have to conduct literature research for these questions.

d) What happens when two males are placed in the same area (a cage)?

e) How do pocket gophers spend the winter? Do they hibernate? If not, where do they burrow? Where do they put the dirt? Can you obtain photographic evidence of winter activities?

WINTER CONSIDERATIONS

Problem 3e is suitable for winter. Runways under the snow can be studied in many areas.

PROJECTS USING TREE SQUIRRELS

CAUTION: Check the local game regulations before collecting or culturing these animals.

PROBLEM 1. Is any tree a potential squirrel tree?

Suggested Design:

Select a number of different habitats. You may wish to study:

a) An open dry area, a semi-open dry habitat and a tree covered wet area;

b) A white spruce dominated area, a black spruce dominated area, and an aspen-poplar dominated area;

c) Pure stands of spruce,pine, birch, poplar, etc.;

d) Muskeg areas covered with willows, etc.; muskeg areas covered with larch, etc.

Determine the relative number of squirrels in a chosen study area in each habitat. One method is to select a point in the woods, sit down and count the squirrels seen in 30 minutes of watching. The distance to the farthest squirrel seen defines the "area" of the sample. Counts in summer should be made between 6 and 9 a.m. This method works best in areas with a heavy tree cover.

Another method providing supporting evidence is to count the number and determine the size of midden heaps in each habitat. A midden heap is the mound of discarded spruce or pine cones scales which have been husked for the seeds.

Questions:

Was your count checked by another individual? Did you check your count on different days? Did you check it at different times? Did you find a preferred habitat? Why do you think it was preferred? Did you measure differences in factors such as; soil type, density of trees, type of trees, height of trees, etc., to determine why one area may be preferred? Did you project the advantages of these factors for all seasons? How does the activity of squirrels insure an adequate food supply for future squirrels? How do humans insure an adequate food supply for future humans?

PROBLEM 2. Do squirrels have a home range?

Suggested Design:

Select a squirrel-rich study area. Using either the method suggested in problem 1 or by live trapping, marking and recapturing (see ground squirrel project) determine how far a squirrel wanders. If you use the observation method you may wish to use four or more observers.

Questions:

If a home range were recorded would it likely be the same size during all seasons of the year? Did you test this? Would it likely be different during mating season? How are home ranges established? How are they defended? What seems to control the size? What would likely happen if you permanently remove a squirrel from a home range? Does the area stay vacant? If not, from where would the other squirrel come?

Did you test this? Was it a male or a female?

PROBLEM 3. More questions requiring experimental answers.

a) When does mating occur? What are the behavioral changes during mating season? When are the young born? How many litters are born per year? What is the litter size? How many survive to adults?

b) Does the number of squirrels in an area remain stable year after year? If yes, what are the mechanisms that tend to keep it that way? Is it control from the outside (predators, hunters, etc.) or control from the inside (small litter size, etc.)?

c) What do they eat? How does this help the trees?

d) Is there meaning in the different sounds made by squirrels? Give evidence for your answer.

WINTER CONSIDERATIONS

The projects could be conducted during any season. Snow tracking would give additional information in winter.

PROJECTS USING GROUND SQUIRRELS

GENERAL METHODS:

COLLECTING:

Ground squirrels, being classified as vermin, may be collected in any manner desired by the collector. The most humane manner possible is, however, strongly recommended. For collecting dead ground squirrels this could mean a variety of methods, the simplest being perhaps the use of a rifle. For live trapping this could mean a well constructed commercial trap such as the "Havahart", the National, the Gen or a home-made trap (Appendix A-17).

CULTURING:

a) Short term (1 week). They may be maintained in any well constructed home-made cage (see Appendix A-18) or in a commercial cage. Strict attention to cleanliness will not only keep the animal contented but will also help reduce unpleasant odors. Food and water must be available at all times. Commercial foods or foods such as fresh grass, shoots, roots, leaves and seeds of both native and cultivated plants are recommended. Do not overcrowd cages. Two animals, preferably of opposite sex, in a cage measuring 2 feet by 2 feetshould be a minimum. Provide the animals with a hiding place such as a Mandarin orange box. Some bedding and nesting materials such as shredded paper and cotton batting should be provided.

b) Long term. Same as the short term culture. Commercial cages and commercial food help ease the load of caring for these animals.

SUGGESTED PROJECTS:

Select one, any number or all of the following as a project.

PROBLEM 1. To determine where ground squirrels prefer to live.

Suggested Design:

Select different habitats and count:

a) The number of ground squirrels in a measured area (e.g., 1000 sq. ft.) over a measured period of time.

b) The number of burrow openings seen in the same area over the same period of time.

Suggested habitats:

a) A short grass area, a tall grass area and the border between the short and tall grass.

b) Shrub area, grass area and the border between shrub and grass.

c) Summerfallow, cultivated crop and the border between summerfallow and cultivated crop.

d) Grass, cultivated crop and the border between grass and cultivated crop.

e) Untouched pasture, grazed pasture, and overgrazed pasture.

f) South facing slope of a hill, north facing slope of a hill and the valley between the two slopes.

g) A field, a roadside ditch and the border between the field and roadside ditch.

Lay out your study area to fit the habitat. For example, if you select a fence line as your area then the 1000 sq. ft. may be in the shape of a rectangle (10 by 100). Counting should be done by sitting in one spot for a set period of time (e.g. ½ hour). Binoculars would be helpful.

Questions:

How many areas did you measure per habitat? Were you the only observer? Was your counting time standard? How many times per day and how many days did you repeat your count? Did you always count at the same time of day? Was the weather similar at the different counting times? Did you find a set ratio of numbers of burrows to numbers of ground squirrels? Were the burrows evenly spaced? How far apart were they? Did you find a reason for the location of the burrows? Did you find the preferred habitat of the squirrels? What anatomical features of the squirrels would make them well suited for the preferred habitat? For example with regard to the Richardson ground squirrel, what might be the adaptive advantage of small ears, a "flicker tail", eyes close to the top of the head, short or long legs, etc.? What behavior patterns did you record for the Richardson ground squirrel which would help them in their preferred habitat? For example, why do they stand on their burrows, why do they bounce when they run, why are they often found on roadsides, why do they live in colonies, etc.? A study of different behavior patterns in different species might prove very interesting.

PROBLEM 2. To attempt to determine why more ground squirrels live in certain areas than in other areas.

Suggested Design:

Select an area where there are lots of ground squirrels and another where there appear to be fewer. Problem 1 might be one method of establishing the relative numbers in each area. Set up a number of smaller study areas (e.g. 100 sq. ft.) within each large study area (e.g. 1000 sq. ft.). Attempt to determine what may be limiting the number of ground squirrels in the total area. You may wish to measure:

a) Dominant vegetation. Determine what, and how much there is in each area. For example, sample 5 one square foot plots in the ground squirrel rich area and the same in the ground squirrel poor area.

b) Dominant vegetation being eaten.

c) Soil type and moisture content. For example, sample 5 tin can cores from each area. The weather component should be considered.

d) Solar energy received in each area. For example, you might measure the light at ground level in the morning, at noon and in the evening in each area. Both areas should be measured on the same day. A camera light meter could be helpful.

e) Territorially. Observe the number of adult males per area and/or the number of adult males per burrow. Capturing animals alive, marking them (try human hair dye), releasing them and recapturing them next day may be very helpful in this project (Appendix A-9).

f) Parasites. Collect the same number (e.g. 5) of ground squirrels from each area. Immediately after death thoroughly search the exterior of the animals for ectoparasites. Hint - Place the animals in a plastic bag, spray with bug killer, put hands in bag and part the hair starting from the nose and working backwards. Collect, count and identify parasites.

g) The number of young per female in each area. If pregnant females are to be sampled, this should happen before the end of April in Alberta. If the number of young are to be counted (e.g. by observation or by live trapping, marking and recapturing) then this can best be done in May and June in Alberta.

h) Predation. Both natural and human. Thirty minute observations at various times of the day might be helpful.

Questions:

Was your sampling accurate? Did you provide for enough duplication? Did you use the same method in each area? Did you determine one factor as being the determining factor? What role does man play in the distribution of ground squirrels? Did you find out if control of population numbers was density dependent or density independent? Was the control imposed on the ground squirrels from the outside or did they impose their own controls? Can you design an experiment to see what happens if you remove predation or increase predation? Can you design an experiment to see what happens if you remove a dominant male from a burrow?

WINTER CONSIDERATIONS

Please ask your teacher for suggestions if you wish to conduct a hibernation project using ground squirrels.

SNOW PROJECTS USING RABBITS, HARES, DEER, ELK, MOOSE

PROBLEM 1. To determine the food eaten by rabbits, etc.

Suggested Design:

The feeding habits of the above have been determined by direct observation, inspection of pellets in feeding areas, examination of vegetation near tracks in snow, and by analysis of stomach contents. The analysis of stomach contents is a difficult task therefore it is not recommended for this project. Select your own method according to the animal and study area available.

Questions:

Does the food eaten by these animals in winter differ from the food eaten in summer? Does the number of animals in an area affect their food habits? Is one plant sometimes suitable as food during one season but completely unsuitable in another season? If so, what determines the suitability? What changes: the plant or the animal or both? How do they change?

PROBLEM 2. To determine the relative abundance of the above-animals.

Suggested Design:

Select a number of different habitats as study areas (e.g. bush, open area, roadside, creek bed, etc.). Measure a set area (e.g. 1000 sq. ft.) in each study area. Determine the abundance of fresh tracks in the snow in each study area. Abundance will have to be a judgement on your part. One method could be to calculate the percentage of study area covered by tracks. However this percentage would have to be weighed by the number of times a track was used.

Questions:

For how many consecutive days did you count the tracks? How did you know they were fresh? Did you count the tracks at the same time of day? Did you determine when in the 24-hour day the animals were most active? Did you find a correlation between the number of tracks and the habitat? Why do you think there are more mammals in one area than in another? Is it because of food, shelter, predators, hunting pressure, etc.? Do you have any experimental evidence to support your views?

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APPENDIX A

EQUIPMENT AND TECHNIQUES

1. Measuring dissolved oxygen content of water.

   a) The water samples should be of equal volume, somewhere between 20 to 30 ml. each is handy. Put five drops of concentrated sodium hydroxide solution into each sample. Add five drops of concentrated manganese (ous) sulphate solution to each sample. A cloudy white colored solid should form. This color should turn any color from yellowish to brownish black. The more oxygen in the solution, the darker the color should be. This method will tell you which sample has more oxygen, which has less, or which have the same amount, but it will not tell you how much. The next method can be used to determine the amount.

   b) Winkler Method of determining oxygen content. (Steps 1 to 4 should be done at the site. The rest can be completed later.)

      1. Collect a 250 ml. water sample.
      2. Add 2 ml. of manganese (ous) sulphate solution. This can be made by mixing 368 gm. of solid manganese (ous) sulphate in 1 liter of solution.
      3. Add 2 ml. of basic potassium iodide solution.. This can be made by mixing 150 gm. of potassium iodide and 500 gm. of sodium hydroxide to make 1 liter of solution.

4. Mix by gently inverting or swirling the container. Allow 2 minutes for settling then dissolve by adding 2 ml. of concentrated sulphuric acid.
5. Add about 2 ml. of commercial starch indicator.
6. Titrate the sample, using a solution of 0.0250N sodium thiosulphate. Stop when the blue color of the indicator first disappears permanently.
7. Multiply the ml. of sodium thiosulphate used by two to get the oxygen content of the water in parts per million (ppm).

2. To measure salinity of water.

The simplest method is to taste the water. Relative salinities could also be measured using an instrument which will measure the electrical resistance or the electrical charge being conducted by the water. A voltmeter, ammeter, etc. could be used.

3. To measure light in water (Penetration and Absorption).

To determine the limits of visibility one can lower a Secchi disk (Figure 1) into the water and record the depth at which it is no longer visible. If a Secchi disk is not available try constructing one. It could be constructed using a 20 cm. diameter round piece of one-half inch plywood painted as indicated in Figure 1. High gloss paint should be used. A graduated rope should be attached to the center of the top of the disk with screw or nail. A rope with a small weight should be attached to the center of the bottom part of the disk. The Secchi disk is used by lowering it on a graduated rope, noting the depth at which it disappears. The disk is lifted and the depth at which it reappears is recorded. The average of these two readings should be the limit of visibility.

4. A mini-aquarium.

   Practically any glass vessel can be used as a simple aquarium, if a regular aquarium is not available. A 1 kg. jam jar or a 2 quart sealer is quite suitable for keeping animals such as caddis fly larvae, snails, small crustaceans, etc. and plants such as Lemna. Care should be taken not to overstock the aquarium. Plants should be kept to a minimum. Treat it the same as any other aquarium, that is:

   1. Place about 3 centimeters of clean sand or silt in the jar.
   2. Fill with water, preferably natural water. If tap water is used, allow it to stand for about two days before adding it to the aquarium.
   3. Stock with submerged water plants. Do not overstock.
   4. Place animals in aquarium. Try to keep predators separate i.e. some beetles and aquatic bugs, and try to include a few snails.

5. Aquarium.

   A glass aquarium about 50 cm. by 25 cm. is a useful size. Treat it in the same manner as the mini-aquarium. The addition of a few larger rocks to serve as hiding places for some water insects and/or fish may be helpful.

6. pH.

The pH of water can be measured in a number of ways. The simplest is the measurement with some pH paper.

7. Wormery.

A wooden box 30 cm. by 30 cm. by 15 cm. fitted with a glass front is useful for studying the habits of earthworms (Figure 2). Fill the box to the top with at least two layers of sand, leaf, mould, and loam, patting down each layer before adding the next. Place lettuce, dead leaves, carrots, etc. on the surface layer. Dampen and add worms. Keep the contents damp but not wet. Do not allow food to get mouldy. The glass side should be covered with a dark material except during actual observation periods.

8. Nets.

A useful aquatic sampling net may be made using a round stick (broom handle), a wire coat hanger, and an old nylon stocking (Figure 3). Two grooves should be cut into the broom handle as shown. In addition, two 1/8 inch holes should be drilled through the broom handle at the end of the cuts as indicated. The wire should be bent into a circle and the ends bent as shown. This straight section should then be lashed to the end of the stick with wire or heavy cord. The used nylon stocking should be cut to form a net about 75 cm. deep. This should be fastened to the circular frame by means of stitching.

The same arrangement can be used for an insect sweep net. However, at least two stockings, one inside the other, should be used so as to provide additional strength.

9. Lincoln -- Peterson Index.

This index is used to determine the total population of animals in a study area. It is based on recapturing animals which have been previously captured and marked in some way. The formula is:

$$P:M::p:m$$

P equals the total population, M the total number of individuals marked, p the total number of individuals taken at the second collection, and m the number of marked individuals taken at the second collection. Therefore, if 10 individuals were marked, and at a later date 15 individuals were recorded, of which 5 were marked, then the total population would be:

$$P \text{ equals } \frac{10 \times 15}{5} = 30$$

10. Formicarium.

One of the best Ant cages for studying purposes is a tall, narrow glass and wood cage (Figure 4). Obtain two pieces of window glass both approximately one foot square. Five pieces of wood each about two inches wide and twelve inches long complete the material required. Cut groves wide enough to hold the glass about ¼ inch from the sides on three pieces. These are the two sides and the bottom. Use the other two pieces to construct a tight fitting top. Use masking tape to hold it together. The same instructions as given for the short term culturing methods can be used to maintain a culture in this type of formicarium.

11. Terrarium.

Any large container which will allow the control of humidity and temperature, and which will hold water is satisfactory. An aquarium tank is ideal. In all cases an attempt should be made to duplicate or simulate natural conditions for the animal under study. For example, if an animal normally lives in a bog, then bog conditions should be created for him.

12. Sour Cream Bags.

The oxygen in a container can be lowered at a steady rate by the use of sour cream in polyethylene bags. Place the sour cream in the bag (about 3/4 full) seal, and place the bag on the surface of the water. The polyethylene bag must be of the type which would allow for the exchange of gases between water and sour cream.

13. Cockroach Trap (see Figure 5).

14. Small Mammal Live Traps.

A variety of home-made traps are used. Figure 6 shows just a few of these. The following description by Brown, _et_. _al_. (1968) should help you construct the trap illustrated in Figure 6(d).

> "The trap and its separated components are shown in Figure 1 (6). The trap element is constructed of aluminum tubing, 1.5-inch outside diameter by 1.5-inch long, and two stainless steel strips cut from .003-inch thick shim stock to 1-inch by 3-inch size. The stainless strips are notched and bent so they bear lightly against each other when riveted to the tubing. The body of the trap is cut from 1.25-inch polyvinyl chloride plastic water pipe stock (inside diameter, 1.5 inches) to a length of 9 inches. Two short cuts into one end of the body tube facilitate the friction-fit attachment of the trapping element. The closure cap is formed by forcing a piece of 1/8-inch mesh hardware cloth, 2.5 inches in diameter, through a short piece of 1.5-inch plastic water pipe (inside diameter, 1.75 inch). The plastic and aluminum tubings are easily cut to desired size with a bandsaw, and rough edges can be removed with any sharp handtool. Fifty of these traps were constructed in 4 hours by two of us at a cost of 50 cents per trap."

Commercial traps such as the Longworth or the Sherman are also popular. Any type of container where the mouse can get in but not back out can, of course, serve as a live trap.

15. Small Mammal Snap Traps.

The snap trap generally used is called the Museum Special. You may wish to try the ordinary type of mouse trap.

16. Small Mammal Cages.

Dyke (1970) recommends the use of commercially produced plastic cages. She says they are light, easily cleaned and have convenient accommodations for food and water. These are important considerations. Before you attempt any home-made cages, write to The Animal Welfare Institute, P. O. Box 3492, Grand Central Station, New York, New York 10017 to obtain a free copy of their book called Comfortable Quarters for Laboratory Animals. They will provide ideas on how to keep your animals healthy and happy. Figure 7 gives one example of a home-made cage.

17. Ground Squirrel and Pocket Gopher Live Traps.

See Figure 8 for some examples of traps. A description of the Steiner modification of the Prychodko Trap and the Gen Trap, manufactured by the Gen Manufacturing Company, Lethbridge, Alberta, are included for your convenience.

Prychodko Trap:

"The trap (Figure 8a) has the form of a helix, made from iron or steel wire." Steiner uses welding rod. "A convenient diameter of the wire for traps for small species of ground squirrel has been found to be 2.5 mm. The diameter of the trap must be slightly smaller than the diameter of the squirrel's burrow. The separate turns of the helix are prevented from straightening by interlacing on three or four sides with thin soft wire, 0.5-0.7 mm. in diameter. The trap must be somewhat longer than the body of the ground squirrel. One end of the helix must be closed, so that the animal will not be able to go through. This can be simply done by making the last turn of the helix much smaller, and by interlacing with thin wire. At the other end, the entrance, the first turn of the helix must be 2-3 mm. smaller than the other. In this way a wire loop or "tongue" attached on one side of this turn can be easily opened into the trap, but is prevented from opening out."

Steiner uses a double diamond "tongue" - Figure 8(a).

Gen Trap:

"The trap (Figure 1 (8)) consists of a galvanized metal cylinder 27 cm. long and 7.0 cm. in diameter. At one end of the cylinder a metal door that opens inward only, 7.3 cm. in diameter, concave 0.5 cm. in its horizontal axis, was hinged so that it could open and close freely. The concave door lies almost flat on the floor of the cylinder, thus providing maximum clearance in the open position. A 14-gauge wire was soldered on the inside circumference along the edge of the cylinder so as to serve as a door stop when in the closed position and also to provide a smooth hinge pin for the door. The other end of the cylinder was adapted to accommodate the lid of a screw-top jar. The lid, which was fitted with a screen, could be opened to release the animal.

The trap is positioned in a burrow so that the door, when it is open, lies against the bottom of the cylinder. Once the squirrel enters the cylinder and crawls past the door it slips on the smooth metal surface shutting the door by the slipping action of its hind legs and keeping it shut by the weight of its body at rest. The most suitable angles at which to set the trap are between 20 degrees and 60 degrees from the horizontal (Figure 2 (8)). However, squirrels were caught when the traps were set horizontally and vertically. The angle of the trap depends on the angle of the burrow."

Remember to tie your trap securely to a stake so as to prevent the loss of both animal and trap.

18. Ground Squirrel Cage.

A cage 20 inches long, 22 inches wide and 18 inches high with a 2- inch false bottom is suitable. A connecting hole should be cut in the side and a three-sided nesting box about 13 inches by 8 inches and 10 inches high should be placed against this connecting hole. A door should of course be provided. The false bottom should be covered with newspaper and the newspaper should be changed daily.

Suggested Materials:

The cage should be coarse stiff hardware wire. The ground squirrels will cut their noses and paws on thin wire such as chicken wire. The nesting and resting box could be wood. A Mandarin orange box is fine if the cracks are closed. The squirrels need a quiet and dark place.

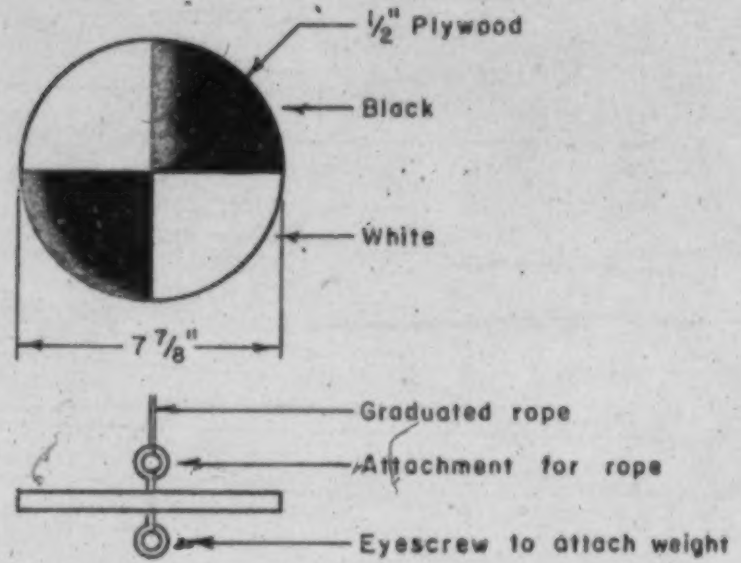

½" Plywood
Black
White
7 ⅞"
Graduated rope
Attachment for rope
Eyescrew to attach weight

Figure 1

SECCHI DISK

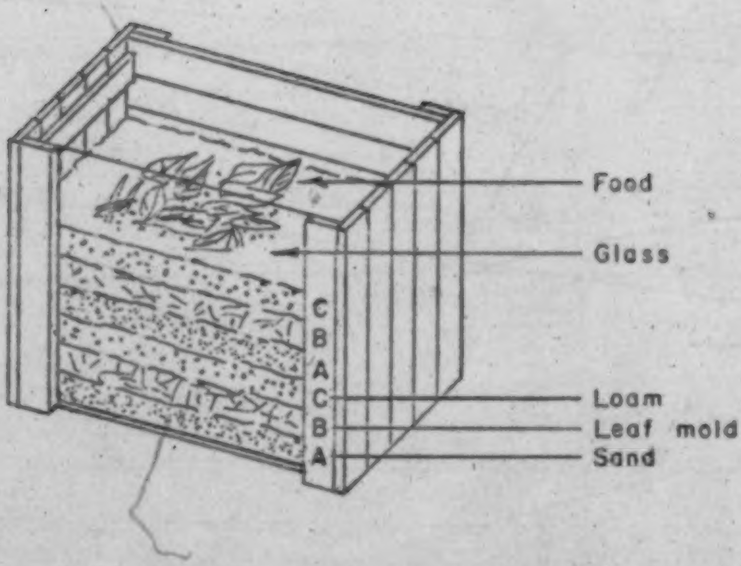

Food
Glass
C
B
A
C
B
A
Loam
Leaf mold
Sand

Figure 2

HOME - MADE WORMERY

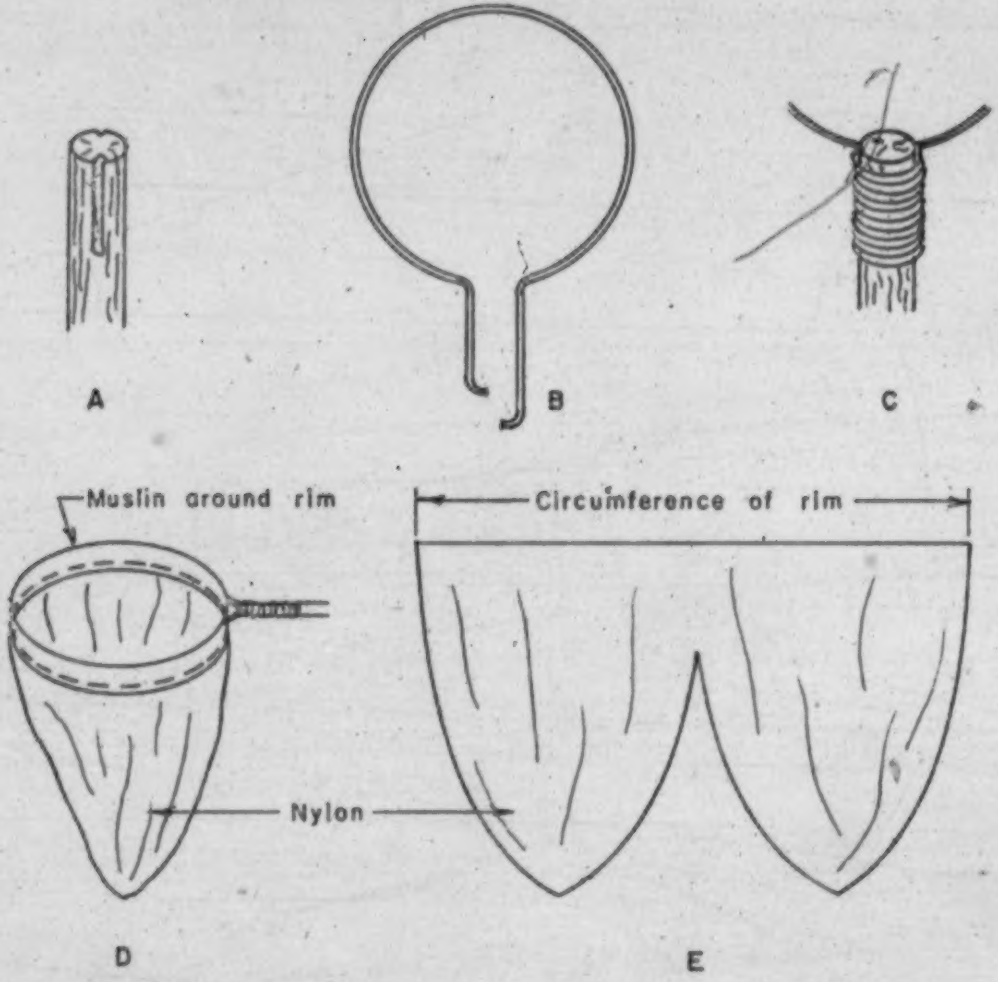

A
B
C
Muslin around rim
Circumference of rim
Nylon
D
E

Figure 3

HOME - MADE NET

Grooves and holes are cut in the end of the handle, as in A, the wire for the rim is bent as shown in B and fitted into the holes and grooves, and held there with a heavy cord or wire (C). The material for the bag is cut as in E, and the finished net is shown in D.

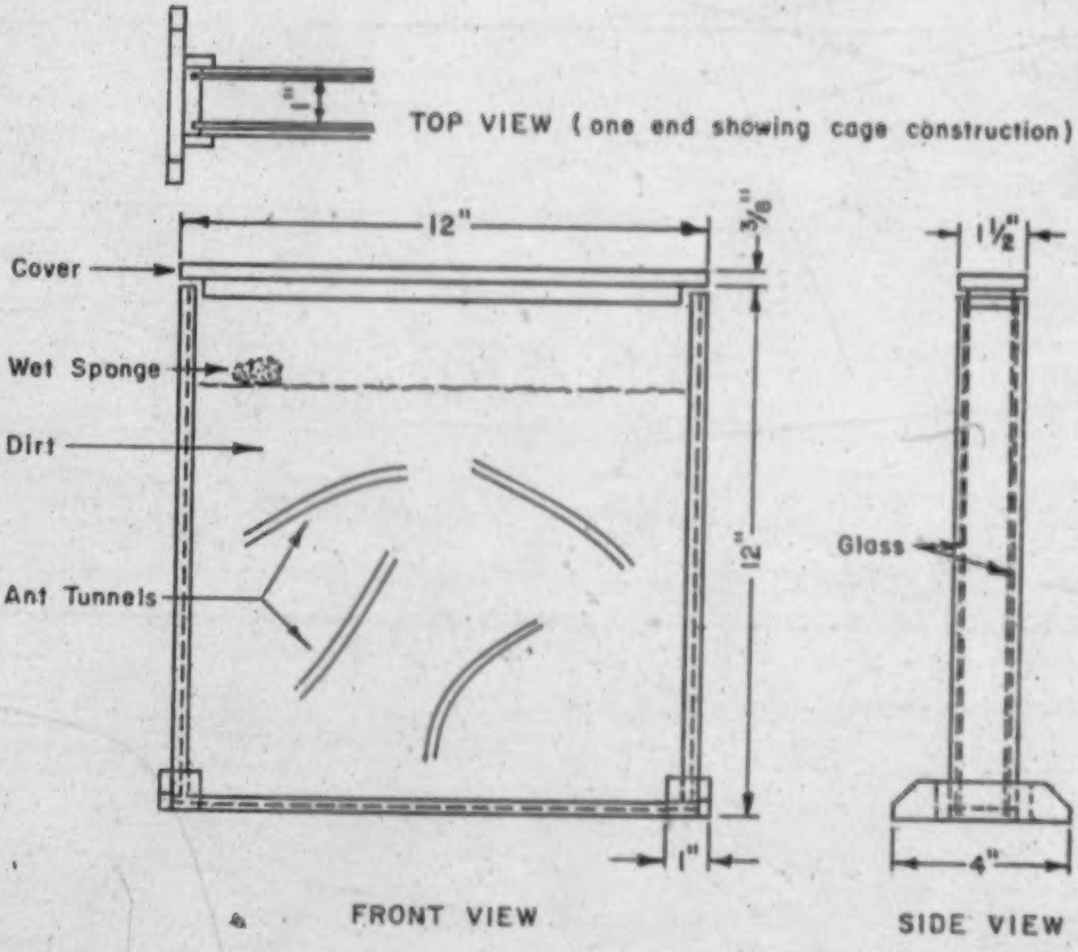

1"
TOP VIEW (one end showing cage construction)
12"
3/8"
1 1/2"
Cover
Wet Sponge
Dirt
Ant Tunnels
12"
Glass
1"
4"
FRONT VIEW
SIDE VIEW

Figure 4

VERTICAL TYPE OF ANT CAGE (FORMICARIUM)

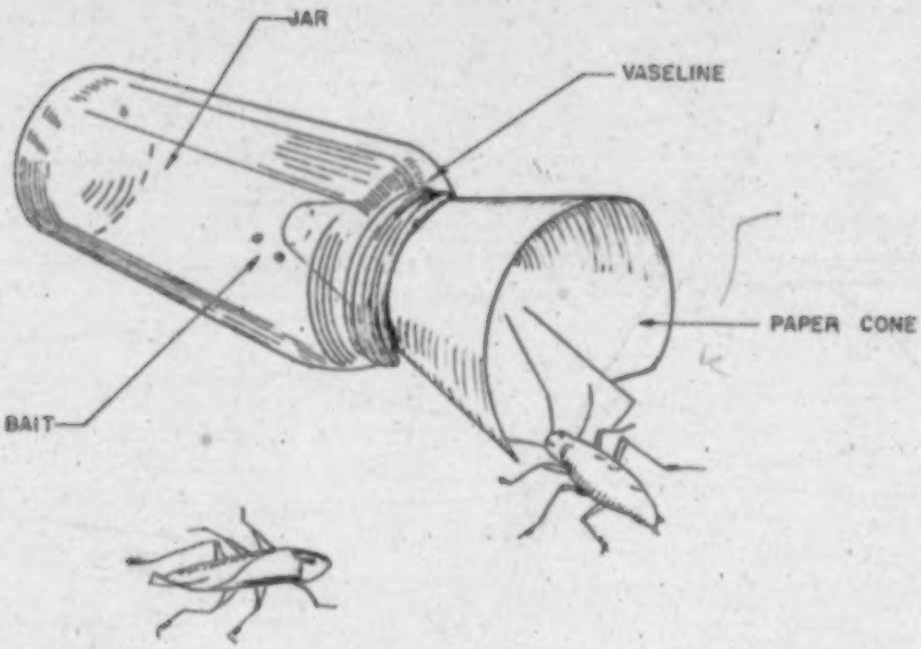

JAR
VASELINE
PAPER CONE
BAIT

Figure 5. COCKROACH TRAP

From Canada Department of Agriculture Publication 924, 1962.

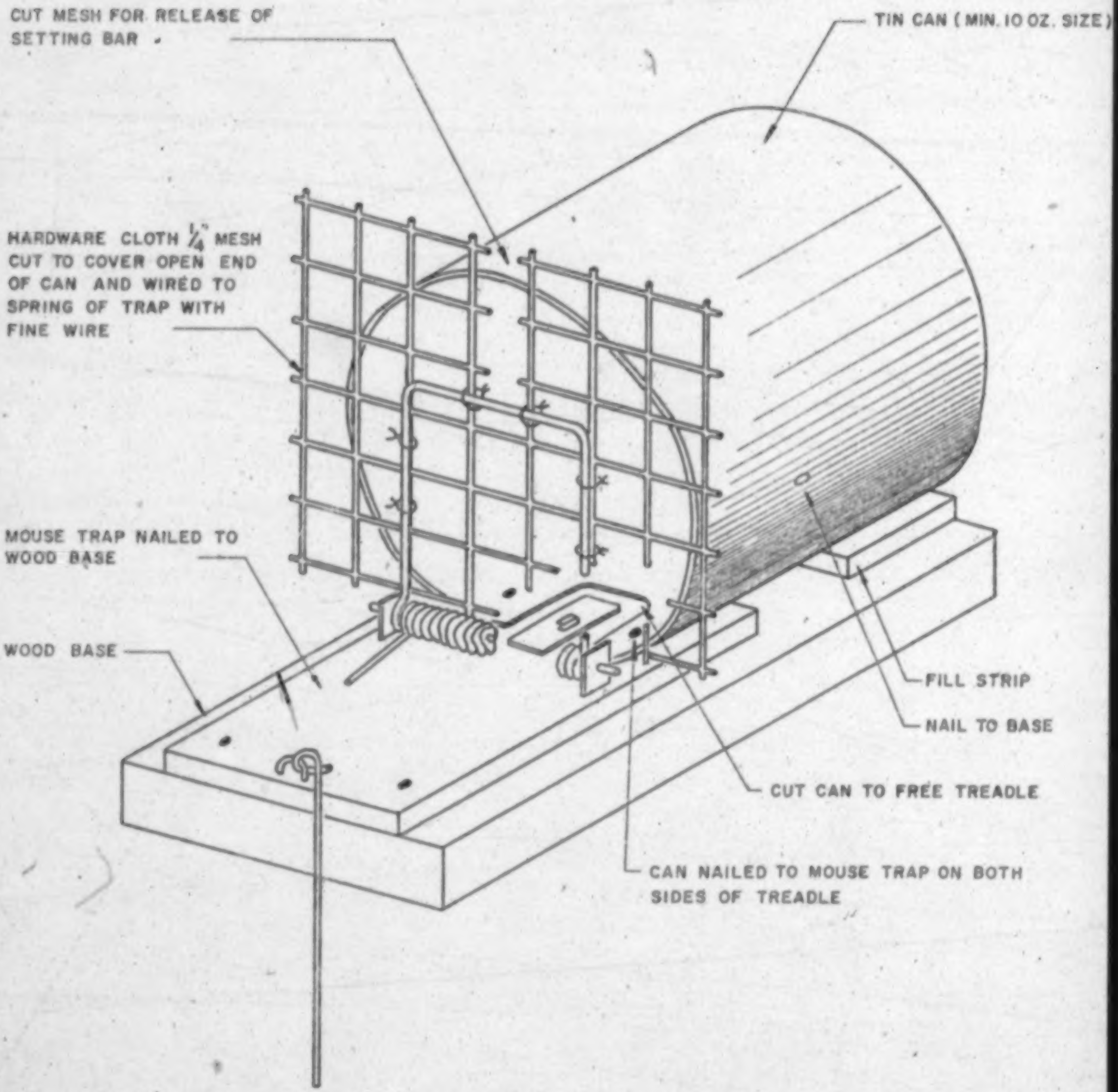

CUT MESH FOR RELEASE OF SETTING BAR
TIN CAN (MIN. 10 OZ. SIZE)
HARDWARE CLOTH 1/4" MESH CUT TO COVER OPEN END OF CAN AND WIRED TO SPRING OF TRAP WITH FINE WIRE
MOUSE TRAP NAILED TO WOOD BASE
WOOD BASE
FILL STRIP
NAIL TO BASE
CUT CAN TO FREE TREADLE
CAN NAILED TO MOUSE TRAP ON BOTH SIDES OF TREADLE

Figure 6 JUICE CAN SMALL MAMMAL LIVE TRAP

From Scheffler, 1934.

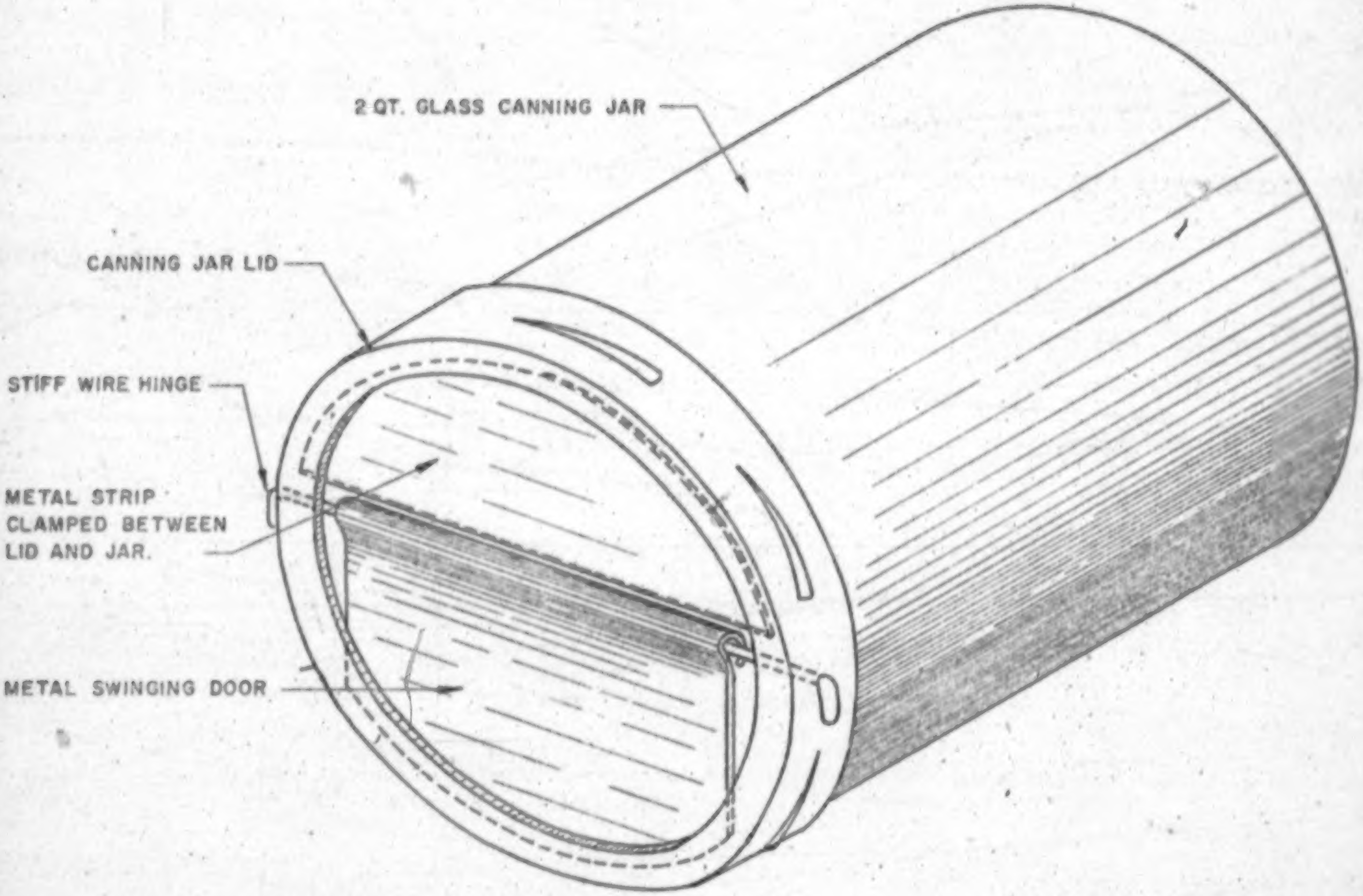
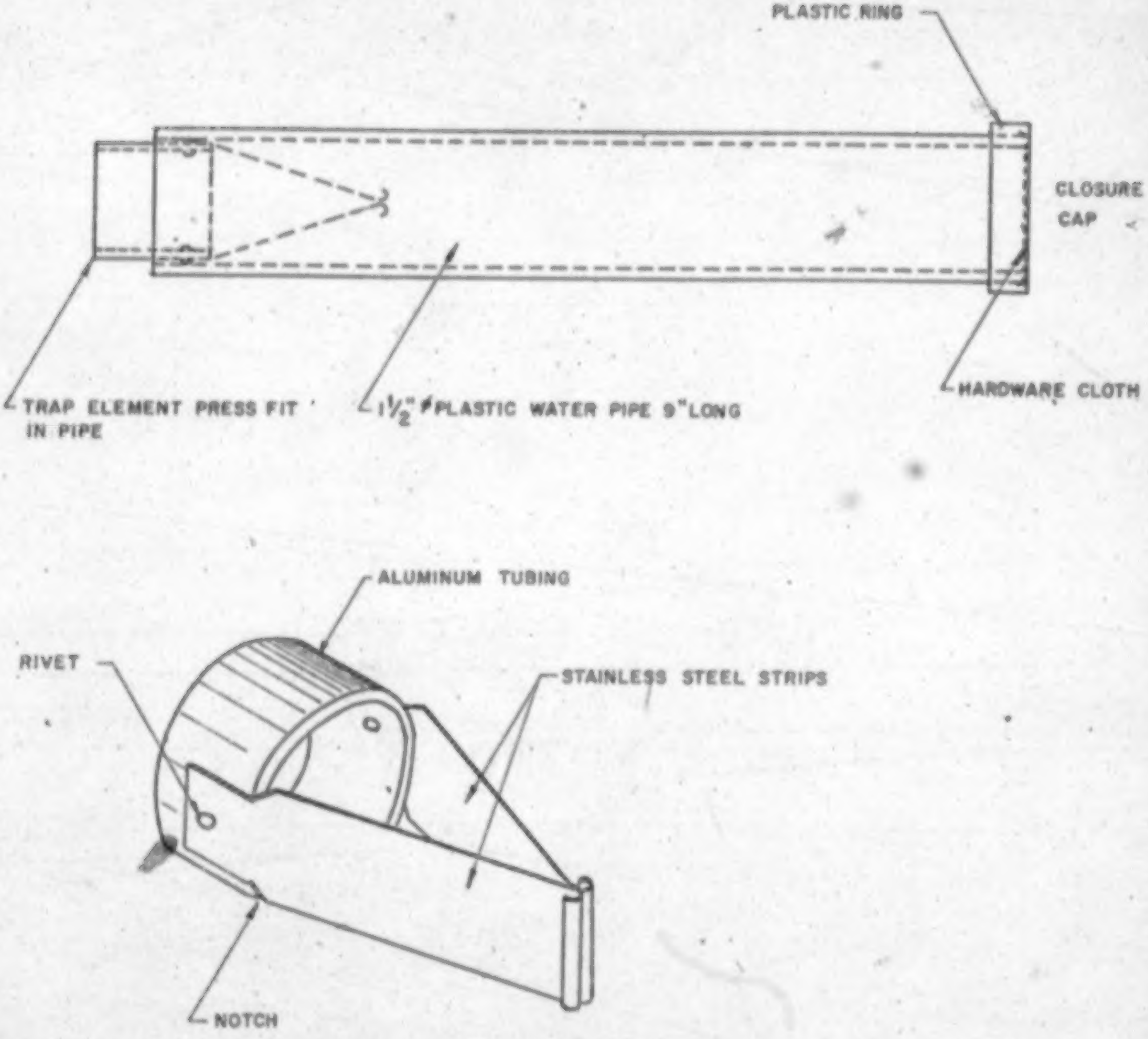

2 QT. GLASS CANNING JAR
CANNING JAR LID
STIFF WIRE HINGE
METAL STRIP CLAMPED BETWEEN LID AND JAR.
METAL SWINGING DOOR

Figure 6 MODIFIED HORNE SMALL MAMMAL LIVE TRAP

From Phillips, 1964.


PLASTIC RING
CLOSURE CAP
TRAP ELEMENT PRESS FIT IN PIPE
$1\frac{1}{2}$" # PLASTIC WATER PIPE 9" LONG
HARDWARE CLOTH
ALUMINUM TUBING
RIVET
STAINLESS STEEL STRIPS
NOTCH

TRAP ELEMENT

Figure 6 PLASTIC TUBE SMALL MAMMAL LIVE TRAP
From Brown, 1968.

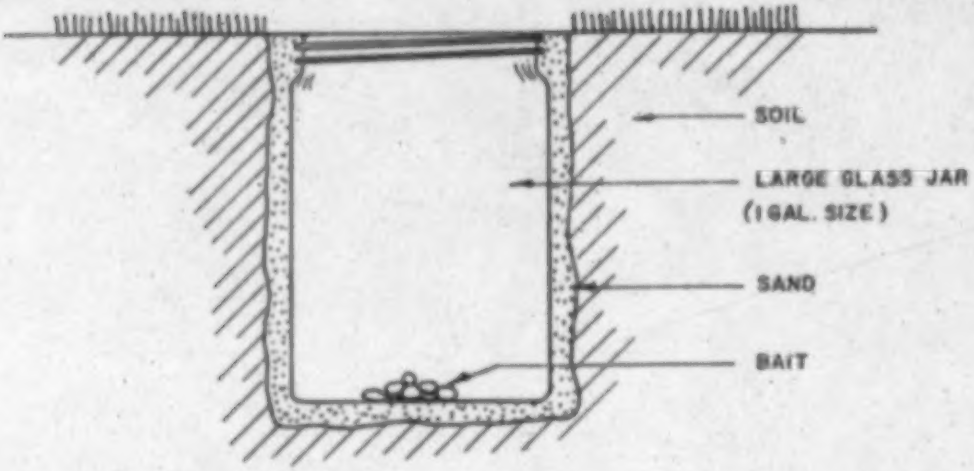

SOIL
LARGE GLASS JAR (1 GAL. SIZE)
SAND
BAIT

Figure 6 SMALL MAMMAL LIVE TRAP

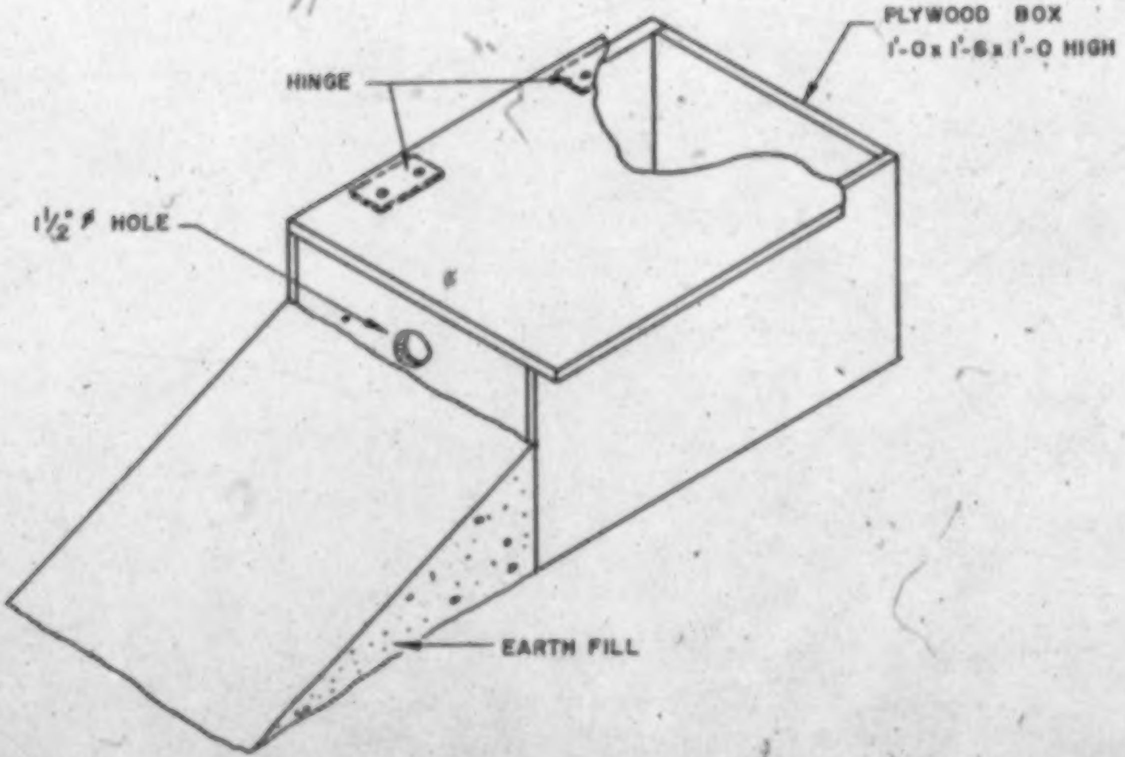

PLYWOOD BOX 1'-0 x 1'-6 x 1'-0 HIGH
HINGE
1½" ∅ HOLE
EARTH FILL

Figure 6 BOX TRAP

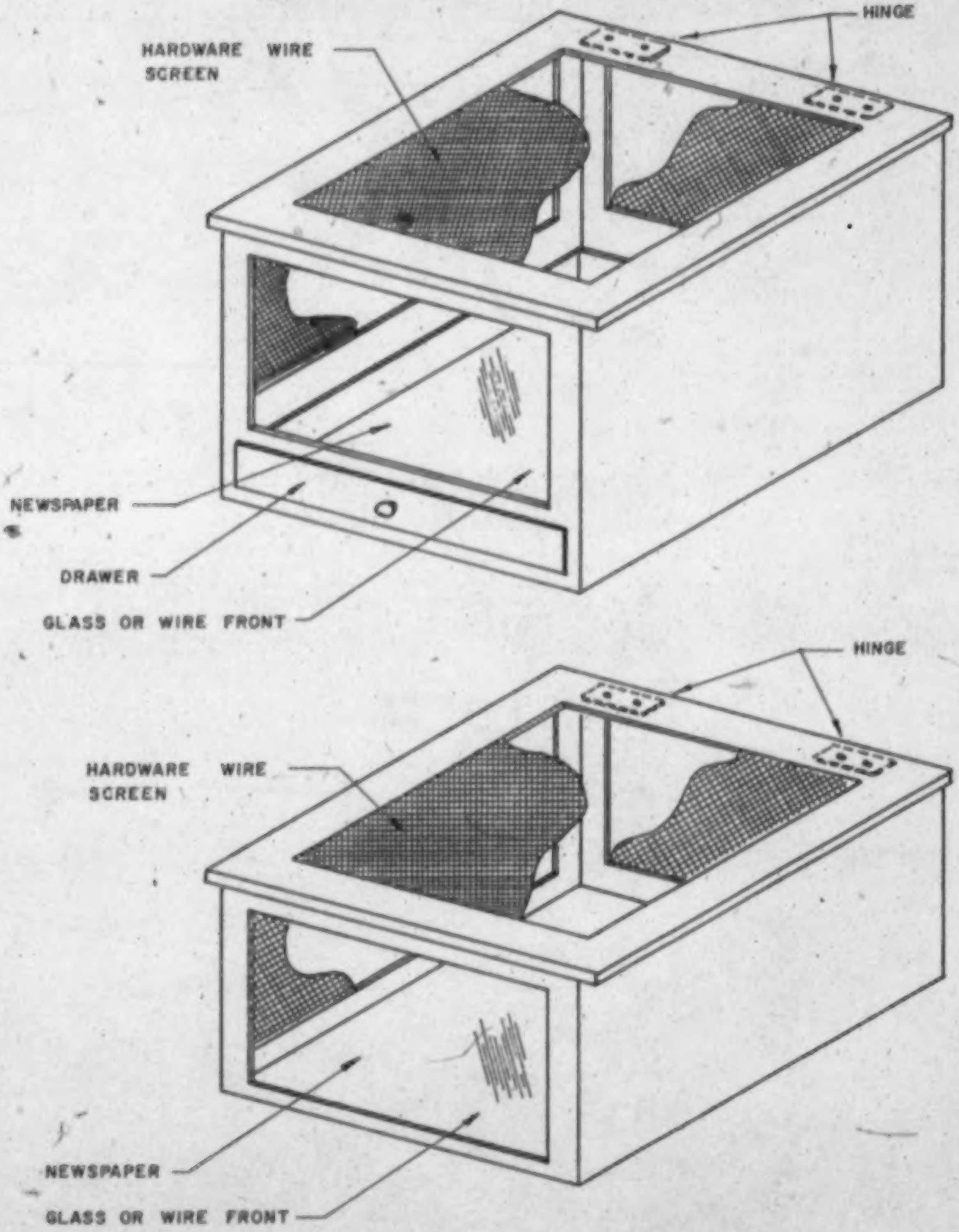

HINGE
HARDWARE WIRE SCREEN
NEWSPAPER
DRAWER
GLASS OR WIRE FRONT
HINGE
HARDWARE WIRE SCREEN
NEWSPAPER
GLASS OR WIRE FRONT

Figure 7 SMALL MAMMAL HOLDING CAGE

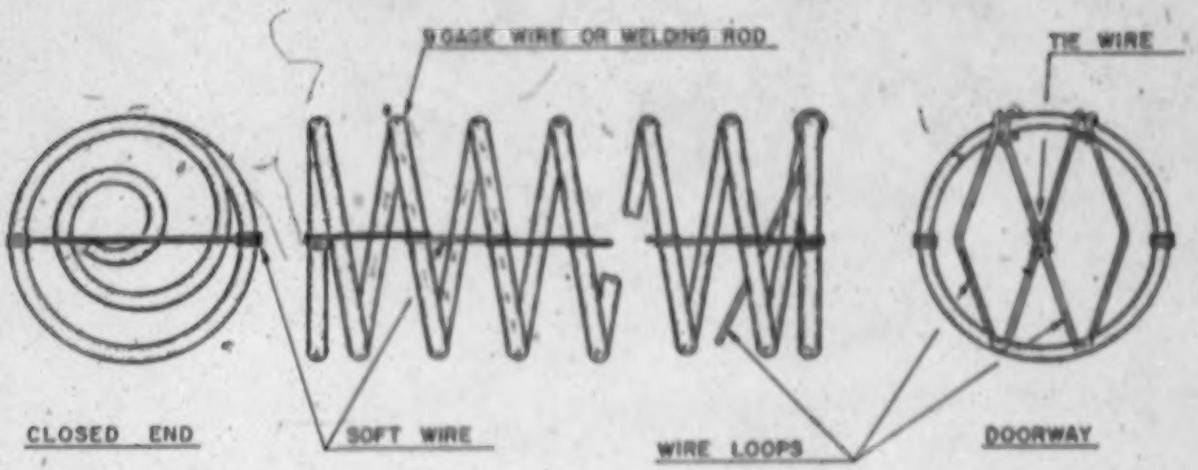

9 GAGE WIRE OR WELDING ROD
TIE WIRE
CLOSED END
SOFT WIRE
WIRE LOOPS
DOORWAY

Figure 8(a) GROUND SQUIRREL OR POCKET GOPHER LIVE TRAP

From Prychodko, 1951. Modifications by Steiner (personal communication)

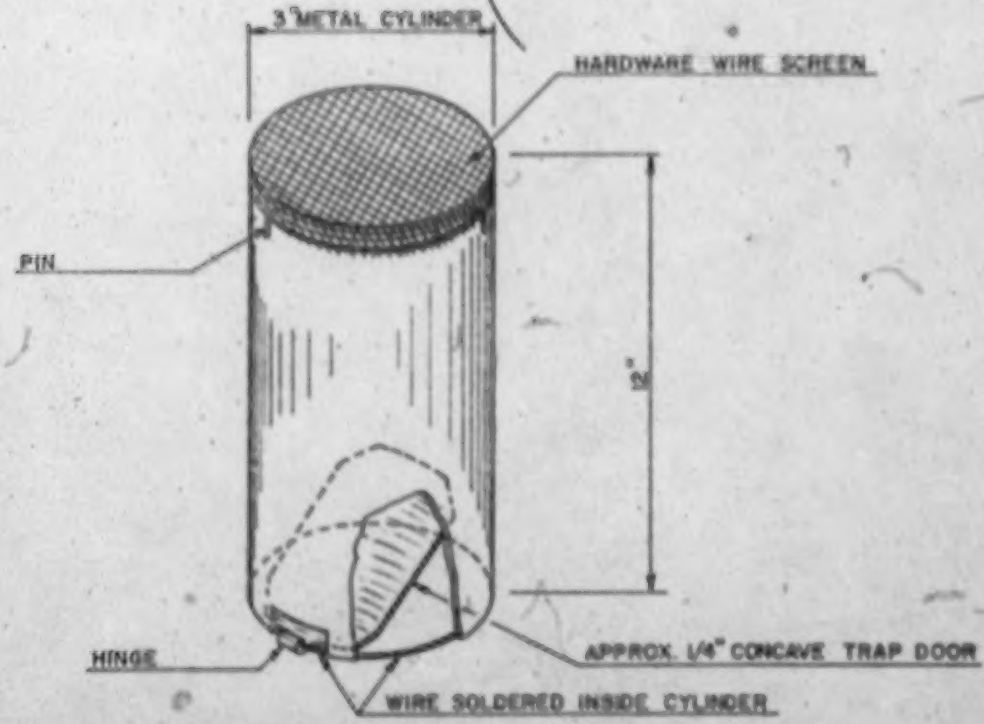

3" METAL CYLINDER
HARDWARE WIRE SCREEN
PIN
12"
HINGE
APPROX. 1/4" CONCAVE TRAP DOOR
WIRE SOLDERED INSIDE CYLINDER

Figure 8(b) GROUND SQUIRREL OR POCKET GOPHER LIVE TRAP

The modified Gen Trap from Shemanchuk and Bergen, 1968.

SECTION III

ECOLOGY - PROJECTS

TEACHERS' SECTION

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INTRODUCTION

This Ecology-Pollution Project book is designed as a teaching aid. As a teaching aid, it may be used in any manner compatible with the objectives of the classroom teacher and with the interests of the students. If learning to recognize some animals in their environment is the objective, then the information presented in the section on collecting and viewing methods is probably adequate. The students could either be given the information or guided to discover it. The entire class could collect one animal or small groups of animals or, alternatively, individual class members could collect different animals. A number of variations are possible. The same variations are possible in using the culturing information presented for each animal. A range of projects is possible if animals are properly cultured. If learning about ecology and pollution or if learning how to inquire is the objective, then any suggested project could be selected. Selection could be made on the basis of student interest and knowledge, on the teacher's wish to illustrate a certain concept or principle, or on the available animals and the time factor. Regardless of the manner in which this book is used by the teacher he should be aware of the following points:

1. The projects suggested do not contravene any legislation regarding the collecting, handling or care of animals. They are in fact designed to develop an attitude of reverence toward life. The teacher could help develop this attitude by insuring that the

handling of any animal at any time is conducted in the most humane way possible. Urging the students to return animals to the area from which they were collected may help foster this attitude.

2. All the projects can be used to teach the ecological concept: "Living organisms and their non-living (abiotic) environment are inseparably interrelated and interact upon each other" (Odum, 1971).
3. Each project can be completed without reference to the preceding one. Most of the projects, however, move from field observations to laboratory work with that animal.
4. Many of the projects involve the use of aquatic animals. It will probably be found necessary to warn students repeatedly not to use fresh tap water in these cultures. Natural water or tap water which has been aged for two days is required.
5. Most of the projects require the collection of living specimens. Students should not be allowed to release live animals in any habitat other than that from which they originally collected the animals.
6. All of the projects strive to stress the importance of the use of controls, replication, and standard experimental conditions. These cannot be overstressed. The teacher should continually check for these common components of good scientific methodology. The following example may clarify what is meant by these statements.

If one man adds a measured amount of a pollutant to a container and records the change in behavior of one fish he cannot call this a scientific experiment. If he repeats the experiment ten times using ten fish of the same species, size, etc., on each occasion, then he is moving closer to a scientific experiment. If two researchers independently record the same results, more confidence is gained in the results of the experiment. If both researchers had also simultaneously recorded the behavior of the same number of control fish of the same kind, maintained, under normal conditions, then this could be a good scientific experiment. A standard, or a control must be an integral part of every experiment.

7. The projects are designed so that a teacher can provide students with a problem, a suggested design and some leading questions. The student can be left on his own at this point. It is suggested, however, that the reverse method would probably create greater interest and motivation among the students. It may well be better to start with the questions. For example, if a small group of students want some project ideas and the teacher knows of a body of water nearby which might contain hydras, then he might stimulate discussion about hydras. By changing a few words he could use the questions provided. For example, Problem 1 of the hydras project could provide questions such as: Where do we find hydras? Are they found in a special kind of habitat? Are they found on only one kind of plant? What do you think could be limiting the spread of these animals? How could this be determined? The students could then attempt to formulate and pursue their own experimental design. The teacher having been provided with some suggested designs could act as a source of information and ideas.
8. As in any scientific research, any project undertaken may well lead to many more unsolved problems. These unsolved problems may serve

as a source of projects for future students.

PROJECTS USING PROTOZOA

Collecting:

The term Protozoa covers a host of organisms. The collecting method suggested should provide the student with a mixed collection of free-living fresh-water protozoa. If this is the students' first protozoan collecting trip then it might be helpful to suggest that they concentrate on obtaining samples which contain submerged green or rotting vegetation, bottom debris and/or surface scum.

Observing:

The protozoan community is very sensitive to changes in the water. Therefore the students should be urged to examine their collections as soon as possible. The rate of change in the community can be reduced by keeping the collections in a refrigerator. The collected material could be concentrated by pouring some of the water through some fine netting such as nylon stocking. The net should then be inverted and the material placed in a drop of water. The students should then see more animals per drop of water. For microscopic viewing Pennak (1953) suggested using a glass slide containing a small, shallow concavity. The slide could be covered with a cover slip and the edges of this cover slip could be sealed with vaseline to prevent evaporation. Some methods for slowing the animals, such as a viscous solution of methyl cellulose, and for staining the animals such as a small amount of methylene blue, might be helpful.

Culturing:

As mentioned in the students' section, temperature, light and cleanliness of containers are the more important factors to be considered. The type and amount of food is of course also important. Unfortunately the optimum light, temperature and food conditions vary with the specific form of protozoan to be cultured. As a result mixed protozoan cultures maintained under one set of conditions are not too successful. The variety of animals will soon be reduced to those favored by the prevailing conditions. Therefore the student should be urged to attempt the culturing of pure strains. Most of the species may be isolated with a capillary pipette and transferred directly to prepared culture media. Needham, et. al. (1937) and Turtox (1944) provide excellent detailed culturing methods for a variety of protozoans. Two suggested culture media for Paramecium and a few comments regarding the culturing of Didinium are included here for your convenience. LeRoy and Ford in Needham (1937) suggest the following method for culturing Paramecium.

> "Paramecium is a form which is easily reared. From the bottom of a permanent pond the foul-smelling debris is taken and kept in a bowl barely covered with water and at a temperature of approximately 73 degrees F. As the debris fouls, the Paramecium become abundant. From time to time (about once a week) a half-inch cube of fish is added to the bowl to maintain a supply of food. Such a culture as this will carry on for months. It is advisable to select a large race and to rear in separate containers. Should some small forms be present in the new bowls they are usually unsuccessful in the competition with the large ones."

The following is another rather more common method for rearing Paramecium.

Fill bowls such as finger bowls 3/4 full of boiled pond water or distilled water. Add 4 to 5 kernels of wheat or rice which have been boiled for about 3 minutes and also add 12 to 15 pieces of inch-long Timothy hay or oats straw. Innoculate culture medium five to six days later with Paramecium. The population should peak in about 10 days.

Didinium is a carnivore which feeds on Paramecium. It should be obtained in the same collection as Paramecium. Therefore simply feed it some Paramecium.

Sampling Techniques:

The number of samples and subsamples suggested in the projects might confuse the students. Consistency in sampling must be stressed to obtain any meaningful comparative results. For example the field samples must be taken at the same depth, at the same time of day, using the same method. If the water is disturbed in one area prior to sampling then the water should be disturbed in the same manner in the other sampling area. Results can only be compared if sampling techniques are the same for all samples.

Possible sampling errors could be:

a) Subsamples taken at different times after collection. As mentioned, mixed cultures change rapidly. Therefore a subsample taken from one field collection on day one after collection can not be compared with a subsample taken from another field collection on day two after collection.

b) Subsamples taken at different depths in the jar. Surface samples in one jar should be compared with surface samples in another jar and not with bottom samples.

c) Different amounts of water observed. If 10 drops are subsampled in jar one then 10 drops should be subsampled in jar two.

PROBLEM 1.

The collections will provide the student with a confusing variety of animals. The student should not be allowed to get lost in the variety. Urge the student to look for dominant animals and for patterns. Example: The most odorous mud produced the greatest number of Paramecium.

Problem 1 provides an opportunity to introduce sampling techniques. The student, of course, is not expected to count the total number of Protozoa in his jar. Instead, the student should sample at random 10 drops of water from his total water sample and determine the number of kinds of Protozoa in this subsample. Discussion regarding the reliability of extrapolating from his subsample to the total jar sample and to the pond could be very fruitful at this point. Students could erroneously assume that Protozoa were distributed equally throughout the volume of the jar sample or pond, or that the distribution of Protozoa in the jar sample was the same as the distribution in the pond.

PROBLEM 2.

Again to obtain any comparative results, the student must use consistent sampling techniques. It would probably be more desirable for the student to limit the project to a study of the effect of varying one factor only. For example; a fruitful project might be to have a student obtain surface water samples only from one body of water taken at different times of the day. The time of day would be the variable here. For instance if the student selected a body of water containing a green surface scum he would probably discover a relationship between the number of Euglena and the time of day.

PROBLEM 3.

Best results should be obtained if the students observe the collections soon after collecting them. The greater the variety of animals the greater the chance of seeing interactions. The three steps of observation, literature review and experimentation i.e. putting two forms together and observing interactions, should provide some definite results in a short period of time.

PROBLEM 4.

Again do not let students get lost in the variety of forms. The appearance and decline of dominant forms should be recorded, not the appearance and decline of every new protozoan observed or recorded.

PROBLEM 5.

The questions contain a number of different projects. More than one student should be encouraged to work on this problem.

PROBLEM 6.

The ciliate Didinium is a predator on the prey Paramecium. The student has an opportunity to observe a case of prey-predator oscillations. The declining prey population should cause the predator population to decline, thus relieving pressure on the prey. The prey population, under the temporary reprieve, should begin to grow and the oscillation is repeated. If the prey population becomes extinct the experiment should be repeated. This time a set number of prey should be introduced at regular intervals (e.g. every 2 days).

Seasonal Considerations:

Late summer and fall would appear to be the best time for these projects. However protozoans can be obtained during any season. The number collected during winter would be greatly reduced, of course. A good winter project would probably result from obtaining samples from under the ice and comparing the relative abundance and kind from each habitat sampled or noting the change in numbers and kinds as the culture is maintained in the laboratory. Problems 1 and 4 could serve as models for these winter projects.

PROJECTS USING HYDRAS

Collecting:

Generally speaking, students should have more success collecting hydras in the spring and summer than in the fall. The varied reasons for this can be used as an ecological lesson. For example, in Alberta different species are found in different habitats. The species found in small bodies of water which are subject to late summer reduction in water level with the accompanying rise in temperature and pH, is often a hermaphroditic species. Organs of both sexes will quickly develop on one animal if one or a combination of the above conditions occur. "Overwintering" eggs will soon be produced. Another species is generally found in the larger bodies of water which do not suffer the great changes in conditions. This species has separate sexes and appears to produce eggs as a result of a steadily decreasing temperature. One reacts in somewhat the same way to an increase in temperature as the other, to a decrease.

Culturing:

Hydra can be successfully cultured in an artificial medium. This medium must contain calcium ions but must be free of copper ions. Loomis and Lenhoff (1956) recommend the following stock solution of modified tap water:

$NaHCO_3$	20 g
Versene	10 g
$CaCl_2$	50 mg
tap water	1 liter

The Versene is a chelating agent used to tie up the copper while the $NaHCO_3$ is introduced for pH control. Versene should be available from a biological supply house. The writer has maintained healthy cultures using a stock solution of:

0.5 gm $CaCl_2$

22.5 cc of Neptune stock solution (a proprietary brand of artificial sea salt)

10 liters of deionized or distilled water.

The absolute numbers of the ingredients can of course change; only the ratios are important.

The culturing method suggested by Loomis and Lenhoff (1956) was found to be very successful. In essence it entails placing hydras in 1000 ml finger bowls containing the stock solution and feeding them daily (or twice a week) on the nauplius larvae of the brine shrimp Artemia salina. Stagnation and contamination of the cultures is avoided by changing the culture medium within one-half hour and again about eight hours after feeding.

Points regarding culturing:

1. Feeding:

The dried and stable eggs of Artemia salina may be purchased in most pet stores. Instructions for raising these brine shrimps are provided on the containers. To collect the larvae shine a light at one side of the container, remove the active larvae with an eyedropper and collect by squirting the contents of the eyedropper through a fine meshed net. The net and its contents should then be washed with fresh water (distilled or aquarium) to remove the salt. Invert the net into the hydra dish.

2. Cleanliness:

As mentioned, the culture medium should be changed within one-half hour and again eight hours after feeding. The water should be changed daily even if the animals are not fed daily. If this is impossible (e.g. weekends) then the culture should be placed in a cool environment i.e. refrigerator. The sequence of water change should begin by running a finger over the inside of the finger bowl thereby dislodging all attached hydras. The hydras and the water should then be poured into another container. The culture bowl should be cleaned and refilled with fresh culture medium. The hydras can then be put back into the culture dish. Swirling the holding water with an eyedropper thereby forcing the hydras to gather in the center of the bowl helps to increase the efficiency of the operation at this step.

PROBLEM 1.

The greatest difficulty encountered with this problem will probably consist of finding the hydras. The writer has collected hydras in all parts of Alberta (Paetkau, 1964), however I have also directed adults to known hydra containing bodies of water, Lake Wabamun, and have had them return without locating any of the animals. One method of alleviating this problem in the future is to record the location and time of year of any hydras obtained by students in your area. This information should be placed in the school file for future reference. A file of this nature could be expanded as information becomes available to include other local plants and animals. It would be a great asset to every new biology teacher in the area.

PROBLEM 3.

Sewage is suggested as one of the pollutants to be tested. Since sewage is a major pollutant and one found in any part of the world it should be included. However, the handling of sewage by inexperienced individuals is not recommended. If a student wishes to use sewage as a test material, he should be advised to first contact the local doctor or local health inspector regarding any possible associated health problems. Checking the potential health problems involved in sewage disposal might also be suggested as a project.

Seasonal Considerations:

As mentioned, late spring and summer are the best collecting times. Large lakes should also contain hydras in the fall. Water which remains ice free and warm all year round should contain hydras at all times.

PROJECTS USING PLANARIANS

Planarians have been classic material for studies in regeneration, in sensitivity to light, touch and chemicals since the early part of the century. Their flat, semi-transparent bodies, mode of locomotion and method of feeding are also very interesting to any student of biology. Recently, they have been used in many studies involved with the phenomena of learning and memory.

Culturing and Collecting:

If students find it difficult to locate these animals, it should be pointed out that most are photonegative and are therefore, found hiding under rocks and debris during the daytime. Culturing problems usually arise when the worms are not provided with suitable dark hiding places. Students should be cautioned not to allow the water to get too warm or foul.

PROBLEM 1.

"Flatworms thrive on any kind of substrate where there is an appropriate food supply. Although they are most characteristic of the shallows, a few species have been collected from lake bottoms as deep as 100 meters" (Pennak, 1953).

This problem could be solved at two levels of difficulty. The simplest level would be to have students determine if flatworms are present or absent in a certain habitat. A more difficult level would be to have students determine their relative abundance in each habitat. Consistent sampling is important for both levels but especially for the most difficult level. If one quart of material is collected at one site then one quart of material must be collected at the second site. If animals are counted 24 hours after collecting from one site then they must be counted 24 hours after collecting from the second site. Results can only be comparative if the sampling and counting methods are virtually identical.

The students should be led to wonder why the flatworms were found in locations containing organic debris. The vital role of these scavengers in an ecosystem and the whole concept of recycling of materials could be discussed in connection with this project.

PROBLEM 2.

The problem could be solved as suggested or could be modified to emphasize the avoidance reactions of these animals. Experiments determining avoidance reactions to light, touch and chemicals could be conducted by a whole class in one or two class periods. The ecological significance of these reactions could be discussed at that time. For example, what adaptive advantage might a flatworm gain by avoiding light?

Seasonal Considerations:

Flatworms can be collected during any season, depending on the water. As noted flatworms are generally not found in very warm, deoxygenated, high pH water. Jacknicke (1968) noted the presence of a few planarians in February from mud and vegetation slough bottom samples which had been collected in the fall, dried for approximately three months, and then cultured by the addition of distilled water or aged tap water. Abundant flatworms are found all year round in most warm water.

PROJECTS USING EARTHWORMS

Culturing:

An earthworm culture is relatively easy to maintain. One has to watch that the soil remains moist and cool, that the food presented is not allowed to mold, and that the earthworms are not too crowded. As a rule, the culture should include not more than 40 earthworms per cubic foot of container. Dead worms should be removed immediately. A pane of glass placed over the box will help maintain proper humidity.

PROBLEMS 1 and 2.

The problems suggested should help students see the interrelationship between soil and animals. They should discover that the soil not only determines where the animals can live but that the animals determine the kind of soil that is present in the area. They should also see that the edge between two ecosystems provides more ecological niches than either ecosystem above, and so should yield more species of animals. Other factors such as the nature of the soils or the moisture content of soils will, of course, alter this basic principle. You may wish to refer students to the classic book on the subject of earthworms written by Charles Darwin (1904). It is entitled "The Formation of Vegetable Mould Through the Action of Worms with Observations on Their Habits".

PROBLEM 4.

Caution is urged in both conducting this problem and the interpretation of the results. Before students are allowed to conduct this project they should be urged to read and follow carefully the directions regarding the use of the biocide as printed on the label of the can or bag as the case may be. Supervision by a responsible adult may be necessary.

A control wormery is a necessity in this experiment. The death of any worms in the test container must be interpreted with caution. Deaths can be attributed to the biocide used only if no worms die in the control wormery and if all other conditions are the same in the experimental versus the control wormeries.

Seasonal Considerations:

Earthworms are best collected in the spring and summer after periods of steady rain. They could be made available for the whole school term by collecting and culturing them in the summer.

PROJECTS USING AQUATIC EARTHWORMS

One of the reasons for some of the present pollution problems is that man has not recognized the vital role of decomposition in nature. Production and consumption are often easily recognized, but not decomposition. Aquatic earthworms (oligochaetes) are one of the most active groups of animals involved in the process of decomposition. They are present in most waters, but their abundance rapidly increases with an increase in nutrients and a decrease in oxygen. In fact, the presence of these animals in large numbers and in the absence of other animals, notably the larvae of mayflies, stoneflies, and caddis flies, is often used as an indication of organic pollution. A visit to the local sewage treatment plant may be advantageous at this point. Most sewage plant operators know these animals as sludge worms and realize the vital role played by them in the breakdown of organic matter under low oxygen conditions.

PROBLEM 1.

If the student finds an area with a large number of these worms, he should be encouraged to measure the temperature of the mud and to compare this temperature with mud containing a lesser population of these worms. Since the process of decomposition uses energy and dissipates energy in the form of heat, the worm infested mud should be warmer than the other.

PROBLEM 2.

These worms have the ability to extend the posterior portion of their bodies out of their burrows and to move it rhythmically in the water above the mud. This behavior is used for survival in oxygen poor water. The students should find a correlation between the length of the exposed part of the worm and the oxygen available in the water. They should be cautioned to take the water for oxygen readings from the level of the worms but not to disturb the water when these oxygen readings are taken. Siphoning with a rubber hose could prevent most of the disturbance. Giri (1971) describes an excellent statistical project which could be conducted in conjunction with this project. He also makes the following statements regarding the use of sour cream bags.

> "The dissolved-oxygen content of the water is decreased by floating several polyethylene bags of sour cream on the water of the aquarium. The oxygen demand is created by metabolic activity of the mostly aerobic lipase-forming bacteria and lipolytic molds and yeasts that commonly decompose butterfat. Oxygen depletion will be more nearly complete if the aquarium is covered with glass so that there is no air space above the water."

Seasonal Considerations:

The projects could be conducted during any season but they could best be conducted in the late summer and fall. Some species may be reduced in number or may even encyst in late fall or winter when the water temperatures are reduced. Students could collect bottom debris and mud from sloughs in winter and simulate summer conditions by culturing the material at room temperature. This could be a project in itself.

PROJECTS USING LEECHES

To the layman, all leeches are bloodsuckers. This is not true. Most are predators and scavengers, and only a minority of the species will take blood from a warm-blooded animal. As scavengers, they play a vital decomposition role in the ecosystem. This aspect should be emphasized. Once students rid themselves of the notion that leeches are bloodsuckers, they will probably become very interested in these often brightly colored and interestingly patterned animals.

Disturbances in the water, such as splashing, may help to attract leeches for collecting purposes. Unfortunately, this behavior pattern on the part of the leeches also makes them a nuisance in swimming areas.

PROBLEM 1.

The majority of species live within a few feet of the shore line.

PROBLEM 2.

Leeches are chiefly nocturnal.

PROBLEM 3.

Only a minority of species will take blood from warm-blooded animals. The majority are scavengers and predators. Leeches normally eat at night. Caution must be exercised in the interpretation of the results. Most leeches can live for long periods without food. "True bloodsucking leeches require only an occasional full meal, the stored blood being digested and utilized very slowly. Specimens have been kept for more than two years without feeding" (Pennak, 1953).

PROBLEM 5.

Leeches are generally the predators and snails are the prey.

PROBLEM 6.

The use of chlorine (household bleach) and copper was suggested because these substances are often used in leech infested waters. Chlorine is used in water treatment while copper, in the form of copper sulphate (bluestone) is used in snail and leech control programs.

Seasonal Considerations:

The projects could be conducted in spring, summer and fall. "Winters are spent in a lethargic dormant state buried in the upper parts of the substrate but below the frost line" (Pennak, 1953).

PROJECTS USING POND CRUSTACEANS

Students should have very little difficulty collecting some of these animals. They may experience much more difficulty in identifying what they collect. Identification problems can only be overcome through experience and through repeated use of good keys in books such as those suggested in Appendix B. A number of these animals may also be difficult to culture for long periods of time. Culturing problems can be eased if the cultures are kept cool. Jacknicke (1968) demonstrated that some of the long term culturing problems could be avoided by keeping a stock of frozen or dried pond mud on hand in the laboratory. He obtained samples of mud in spring and fall "from the edge of an aquatic environment where the water had receded, or from the dry bottom of a temporary body of water". He subjected some to drying at room temperature and some to freezing. Aged tap water or distilled water was added to some of the samples in January. Crustaceans (Cladocera, Ostracods, and Copepods) started to appear in a few weeks in the cultures. More success was obtained with fall mud samples than with spring mud samples. Samples that contained vegetation were more successful then those not containing vegetation. He also collected some mud samples from under the ice on

February 6, 1968 and noted the appearance of some crustaceans within a few weeks after culturing at room temperatures. The kind and number of crustaceans appearing in your students' samples would depend on where and when the mud was collected and on which crustaceans withstood the freezing or drying ordeal. A number of winter projects could be conducted by students in an attempt to obtain answers to the question posed in the previous sentence. Problems one and two should provide models for these winter projects.

Seasonal Considerations:

The projects could be conducted in all seasons.

PROJECTS USING GRASSHOPPERS

The habitat and food preference of these animals is revealed by their name. The life history of the prairie grasshoppers is presented as the typical grasshopper life history. Craig (1971) provided most of the information.

Most prairie grasshoppers spend the winter in the egg stage. The eggs are generally laid on egg beds located in roadside sod, borders of sloughs, or scattered throughout stubble fields, etc. The eggs begin to hatch in late spring and early summer, depending on the weather. Students should, therefore, watch for signs of hatching and for newly hatched hoppers in the areas mentioned. The newly hatched hoppers are wingless and only about 1/8 inch long. As they grow they shed their skins five times. At the last molt, they become winged adults. In late summer, the females lay eggs that remain unhatched until the following spring.

Due to their strong habitat preference, grasshoppers well illustrate the interrelationships between plants, animals and soil on and in which they live. As primary consumers they can also be used to illustrate the flow of energy through an ecosystem.

Seasonal Considerations:

The projects could be conducted during spring and summer.

PROJECTS USING COCKROACHES

There are a number of species of cockroaches in Canada. The most common species is the German cockroach. It, like most roaches, likes to live in areas that provide warmth, food, moisture, and hiding places. If suitable conditions are found, the female will lay her eggs in a package or capsule. This capsule, containing anywhere from eight to 48 eggs, may be carried about for some time attached to the tip of the abdomen. The capsule is later generally hidden in a crack or crevice. The period of development from egg to adult may take from three months to a year depending on species and environment.

PROBLEM 1 and 2.

As in all of the projects outlined, these also illustrate the interrelationship between the living and the non-living. Cockroaches will live only in favorable habitats. If the habitat changes through deliberate measures such as cleanliness, then the cockroach will be forced to move. A discussion regarding the various methods of pest control could be based on these projects. The females of many species have shorter wings than the males.

Seasonal Considerations:

The projects could be conducted in all seasons.

PROJECTS USING AQUATIC BUGS, BEETLES DRAGONFLIES AND DAMSELFLIES

The above animals share two common traits. All live in an aquatic environment and most have predaceous habits. It is difficult to determine which animals from these groups will be collected by the students. However, the common names of the most commonly collected individuals may provide enough information so that students can identify the animals with the help of good keys such as those given by Needham and Needham (1962) or Pennak (1953).

Order Hemiptera (Bugs) - water striders (pond skaters, wherrymen); water treaders; back swimmers; water boatmen; and giant water bugs.

Order Coleoptera (Beetles) - predaceous diving beetles, whirligig beetles.

Order Odonata (Dragonflies and Damselflies) - the larva stage is generally collected in aquatic samples.

PROBLEM 1.

As mentioned, nearly all of these animals are predators. Some actively stalk their prey while others lie in wait for it. Some are predators at one point in their life but can change to playing a scavenger role if necessary. The type of food captured varies, of course, ranging from other aquatic insects to annelids, small crustaceans and even tadpoles and small fish. The following information obtained from Pennak (1953) may provide some guidelines for culturing purposes.

O. Hemiptera

"Nearly all aquatic Hemiptera are strict predators, the particular prey, depending on the specific habits of the various genera, being chiefly small terrestrial and aquatic insects and entomostraca."

O. Coleoptera

Predaceous diving beetles

"Exclusively carnivorous and voracious. Feeds on larger species such as dragonfly nymphs, tadpoles and even small fish. Will eat almost any kind of raw or cooked meat."

Whirligig Beetles

"Live insects which fall upon the surface of the water form the main portion of the diet. Some species may feed on dead animal matter and vegetation."

O. Odonata

"All are carnivorous. Eat aquatic insects, annelids, and small crustaceans and mollusks".

PROBLEM 2.

Specialized gills and specialized body hairs are just two examples of unique breathing adaptations in these groups. The student should try to determine if his study animals actually breathe underwater or if they surface to breathe atmospheric air. The advantage of each method in an oxygen poor environment such as a natural slough or polluted water may be discussed.

PROBLEM 3.

O. Hemiptera

"The great majority of species winter over as adults hidden in mud, trash, or vegetation at the edges and the bottom of their habitat. They may often be seen swimming about under the ice, however" (Pennak, 1953).

O. Coleoptera

Predaceous diving beetles

"Ordinarily hibernate in debris or burrow into the bottom or edges of ponds. Not uncommon to see adults swimming under ice in winter. Some species aestivate during a portion of the summer."

Whirligig beetles

Hibernate in mud or trash at the bottom or edges of ponds and streams during cold months. "Adults most abundant in late summer and early autumn" (Pennak, 1953).

Seasonal Considerations:

The projects may be conducted during all seasons. Adults are probably most abundant and most easily obtainable in late summer and fall. However, winter time collecting of debris under the ice should be profitable.

PROJECTS USING TERRESTRIAL BEETLES

"Beetles may be found in almost every type of habitat in which any insect is found, and they may feed on all sorts of plants and animal materials. Many are phytophagous, many are predaceous, some are scavengers, others feed on mold or fungi, and a very few are parasitic" (Borror and DeLong, 1954).

PROBLEM 1.

The problem suggested is a study of the role of scavengers in an ecosystem. Producers and consumers are often stressed in the teaching of biology; decomposition seems to be less so. One of the main reasons for the present ecological crisis is the lack of recognition of the vital role of decomposition. This project should help the student gain an insight into the necessity of recycling in a finite system. Observations and discussions regarding the different ways substances such as bread and plastics fit into the recycling process should provide the students with one reason for the increased pollution problems on this continent.

Seasonal Considerations:

Spring, summer and fall projects would be suitable.

PROJECTS USING CASE BUILDING CADDIS FLY LARVAE

Generally, caddis fly larvae which live in rapidly flowing water do not build cases. Therefore students should be directed to lentic habitats. Cases constructed from leaves, sticks, coniferous needles, gravel and sand are common in these habitats.

The case building habits of these flies are generally very interesting to any one who has been fortunate enough to have been introduced to them. The case construction is usually begun soon after hatching and rebuilding continues until the larva emerges as an adult. Materials are generally selected with the legs from the substrate, and if it is plant material, it may be cut to correct size with the mouth parts. Large glands in the front part of the body produce a gluelike substance used for cementing together the particles of the case. The case is enlarged as the worm grows. Under normal conditions members of the same species select the same material and build cases in the same way. However, sometimes an individual animal may change building material as it gets older. You may wish to discuss the advantage conferred by the habit of each species using different building material. Competition could be severe and, of course, the number of different species might rapidly decline, if all tried to use the same building material.

Caddis fly larvae often form the most important items in the diet of trout.

Seasonal Considerations:

Spring and early summer should be the best time for these projects. At that time of year larvae may be collected in shallow, clean, fresh water habitats.

PROJECTS USING CATERPILLARS (MOTHS AND BUTTERFLIES)

The collecting of adults and the maintenance of cocoons or chrysalids until emergence as adults are, of course, the two most common activities associated with these animals. Even though these activities have not been stressed in the projects suggested they could be used to teach ecological concepts. Students might note the adaptive advantage of the different colors or the advantage to the animal in having different life stages. The projects suggested concentrate on caterpillars because caterpillars are often easiest to catch and can be raised to the other stages if desired.

PROBLEM 1.

A study of the feeding habits as suggested in problem 1 could lead to a discussion of the meaning of the term "pest".

The student might encounter difficulties with this project in that some caterpillars will not eat anything during the period of observation. The first sentence of the problem, suggesting that the student should collect as many different kinds of caterpillars as possible, is an attempt to decrease the chances of this occuring.

The caterpillars should eat at the most rapid rate immediately after moulting.

PROBLEM 2.

The problem should lead to discussions regarding control methods for "pest" species. Insects become pests at times because of a combination of favorable conditions i.e. temperature, moisture, food, lack of competition, lack of predators, etc. Attempt to get the students to relate the experimental conditions to actual conditions which might have controlled the population of a pest species in their area.

Seasonal Considerations:

Late spring, summer and fall should be best for these projects. Cocoons and/or chrysalids could be collected in the fall and some projects as suggested i.e adaptive coloration, etc. could be conducted. The effect of temperature and humidity on rates of emergence could be an interesting winter project.

PROJECTS USING HOUSEFLIES

A brief review of the life history of the common housefly Musca domestica might be helpful. An Alberta Department of Agriculture Bulletin (Publication No. 672) written by R. D. Dixon and L. K. Peterson (1970) provided most of the information. There are four stages.

1. Eggs. Batches of 100-150 eggs per mass are laid. Five or six batches of eggs per female per lifetime.
2. Larvae (maggots). In warm weather these emerge from the eggs within 9-20 hours. Completion of the larva stage requires 3-7 days at temperatures of 70-90 degrees Fahrenheit. Three instars occur during growth then the larva migrates in search of a dry, cool place to pupate, generally the soil under the breeding substance. This is the reason for the soil under the food source - the substance - in the problems. The introduction of a

little damp earth, sawdust, or moss into the jar at this stage may help development to the next stage.

3. Pupa. This stage may last from 3 days to 4 weeks depending primarily upon temperature and humidity.
4. Adults. The female may start laying eggs in 4-12 days. She favors moist materials. She may live about 50 days.

PROBLEM 1.

Fermenting fresh horse manure is a favorite breeding place of the housefly. Houseflies will not breed in pure cow manure, but will breed in cow manure mixed with straw.

"The most effective and desirable method of controlling houseflies consists of eliminating or reducing the breeding places to a minimum by properly treating or disposing of such materials as manure and garbage" (Dixon and Peterson, 1970). A cement floor under a manure pile to prevent pupae from developing is one example of how this can be achieved. A discussion regarding biological control versus chemical control could be very timely after the completion of this problem.

Seasonal Considerations:

The projects should be most successful in the spring, summer and fall.

PROJECTS USING MOSQUITO LARVAE (WRIGGLERS)

There are many species of mosquitoes each with its own characteristic habitat. The problems outlined should help students discover this. General information taken from an Alberta Department of Agriculture Bulletin (Publication No. 673 - 1970) may help guide the students in their research.

There are over 40 species of mosquitoes in Alberta. Most of these belong to the genus Aedes. The mosquitoes in this group can be divided into two subgroups - univoltine (single generation) and multivoltine (many generations). As the following brief life history sketch indicates, both of these are temperature dependent.

Univoltine:

1. Eggs laid singly on damp soil around the margins of ponds, etc.
2. Eggs require cold conditioning (winter) then hatch in the spring into larvae when the oxygen tension is reduced and the water temperature rises over 32 degrees Fahrenheit.
3. Larvae develop to comma-shaped pupae. May take up to four weeks depending on the temperature.
4. Pupae to adults. All adults first feed on nectar, then female adults need a blood meal to lay eggs.

Multivoltine:

1. The life history is the same except that the eggs don't hatch until the water temperature rises over 50 degrees Fahrenheit. Cold conditioning of the eggs is not necessary. Therefore the life cycle is short (7-14 days) and may be repeated a number of times per summer depending on rain and temperature.

Phantom midges:

These belong to the same family (Culicidae) as mosquitoes but in a separate subfamily, Chaoborinae. They are called phantom larvae because of their transparency. They exhibit daily migratory movements, being confined to the bottom of the water during the day and the surface at night. If the student has difficulty in finding these, another predator such as dragonfly or damselfly nymphs might be suggested.

PROBLEM 2.

Rain produces small shallow puddles. If the temperature of this water rises quickly after the rain then the puddles will provide excellent mosquito breeding areas.

PROBLEMS 3 and 4.

Phantom midge larvae are predators on mosquito larvae.

PROBLEM 5.

There are many different individual projects suggested in this problem. Different groups of students within a class could work on different aspects of the problem.

Seasonal Considerations:

The projects could be conducted during spring and summer. Students might try hatching mosquitoes from eggs collected in fall or winter. The hatching water should be well oxygenated. Maintaining cultures at different temperatures or raising the temperature in one culture slowly might provide interesting results. Remember to use pond water or aged tap water.

PROJECTS USING ANTS

Ants will live almost anywhere they can find shelter and protection. This has resulted in a great variety with over 8,000 species having been classified to date. The following information relates more to mound-building ants than to any other kind.

An ant colony generally consists of a queen, males and numerous workers. During certain seasons (mainly mid summer) winged males and females will emerge from the colony, mate and the males will die. The females will fly off to start a new nest. There they will bite off their wings, lay eggs, and care for the hatching young until mature workers appear. After this, they will become mainly or essentially reproductive organs (queens) cared for by the workers.

Collecting:

The best time for collecting ants for the purpose of establishing a colony is late fall, winter, and early spring. At those times they can generally be found crowded together in a cluster below the frost line beneath the mound. Note that most of the ants are found not in the mound but below the mound. The ants are quite sluggish at this time and therefore the chances of capturing a queen are better than in summer.

PROBLEM 1.

"The feeding habits of ants are rather varied. Some are carnivorous, feeding on the flesh of other animals (living or dead), some feed on plants, some feed on fungi, and many feed on sap, nectar, honeydew, and similar substances" (Borror and DeLong, 1954).

PROBLEM 2.

"Ants have various means of defense; many species (all except the Dolichoderinae and Formicinae) can sting, many can bite severely, and a few (Dolichoderinae and some Myrmicinae) give off or eject a fowl-smelling secretion" (Borror and DeLong, 1954).

PROBLEM 3.

When worker ants are foraging for food they generally leave a scent trail for other ants to follow. This trail also enables them to find their way home. The selection of "natural" materials and the rejection of "unnatural" materials such as plastics should lead to a discussion regarding the function of recycling in a finite system.

Seasonal Considerations:

Problem one should be conducted during late spring, summer and early autumn. Problems two and three could be conducted during any season if animals are collected and brought into a warm room so that they become active. The collecting of ants in late fall and early spring could be a project in itself. A study of the mechanisms used by ants to withstand the cold winter and comparisons with other animals should be very interesting.

PROJECTS USING WATER MITES

These animals are most abundant at the shores of ponds and lakes, especially in areas which contain rooted aquatic plants. Their bright, generally red or orange colors, round shapes, scurrying and swimming habits make them interesting animals to observe. Initially, the students may identify them as spiders but a comparison with the body of a spider should immediately show the difference. The most obvious difference is that the body of a spider is generally divided into two segments, the cephalothorax and abdomen, while the body of a water mite is fused into one globular mass.

PROBLEMS 1 and 2.

The most striking feature of most water mites is their color. "Coloration is sometimes correlated with the background, though there is little evidence that the resemblance has any protective value. Elton (1923) found that hungry sticklebacks refused to eat bright scarlet mites, and he postulated possible Mullerian mimicry and warning coloration" (Pennak, 1953).

PROBLEM 3.

Mites are generally cannibalistic when subject to overcrowding. This observation on the part of the students should lead to discussions regarding population control mechanisms. Are these control mechanisms different in mites and men?

Seasonal Considerations:

The greatest number should be available in late spring and early autumn.

PROJECTS USING SPIDERS

Spiders are a large, rather widespread group. They occur in many habitats and are often quite abundant. Many people immediately react with horror when they see spiders, yet only a few spiders notably the black widow spider and the brown recluse spider, are dangerously venomous. The rest are harmless and in fact, very beneficial to man. Their predatory habits, feeding mainly on insects, help keep those animals in check. They in turn provide food for other insects such as wasps.

PROBLEM 1.

This problem should illustrate the great diversity of spiders. Many kinds are found in what appears to be the same habitat. At this point, a discussion regarding the concept of ecological niches and the mechanisms whereby so many different spiders can live together in the same habitat may be fruitful. A discussion of their different behavior patterns as shown by their different webs may introduce the topic. Sampling in two different ecosystems and at the edge where these two meet should also allow the student to discover that the greater the variety of habitats, the greater the variety and number of animals found in the area.

PROBLEM 3.

"The webs built by spiders are of several principal types; each species of spider constructs a characteristic web that is often as distinctive as the spider itself" (Borror and DeLong, 1954).

PROBLEM 4.

Young spiders are sometimes cannibalistic. Fewer young spiders than eggs will therefore escape from the egg sac. Different methods of population control could be discussed in connection with this project.

Seasonal Considerations:

The projects can be conducted in any season, even winter, if spiders and spider webs are available. In most cases spring, summer and especially fall field observations would be most appropriate.

PROJECTS USING FRESHWATER SNAILS

Snails are easily collected and easily cultured. Culturing problems can arise if snails collected from swiftly flowing waters are placed in quiet water cultures. If this does occur, you could use this "mishap" to illustrate the adaptations of animals to their environment. The "mishap" can also be prevented by creating a flowing water system in an aquarium. One method would be to set a pane of glass at a 45 degree angle in the end of the aquarium and to place several air stones under and adjacent to the pane of glass. The pane must be raised off the bottom of the aquarium and the top of the pane must be under the water level thereby allowing the water to circulate under and over the pane. A word of caution regarding the handling of snails might also be in order. Most snails are important intermediate hosts for a number of parasites. Humans, at least in temperate zones, are generally not the preferred definitive hosts. Some parasites, however, such as the metacercaria of Schistosoma, can mistake the warm body of a human for the warm body of an aquatic bird. They will, therefore, burrow into the human skin. The human body will promptly attempt to reject this intruder, the interaction resulting in "swimmer's itch". The last question in problem four relates to swimmer's itch.

PROBLEM 1.

Snails are both herbivores and scavengers. As herbivores, they can be compared with cows or grasshoppers in the terrestrial food chain. As scavengers, they can be compared with any land scavenger.

Calcium is required for shell building. Calcium levels can in part be related to carbon dioxide levels in the water and so can be related to the pH levels in water. A project beckons.

PROBLEM 2.

Most populations that live in ponds which freeze solid or dry up are able to survive by burrowing into the mud, sealing openings with a thin layer of mucus and hibernating or aestivating for the critical period. Mud bottoms with some clay are the most effective refuges.

PROBLEM 3.

Leeches and diving beetles are predators on snails. Incidentally, fishes are the greatest predators.

PROBLEM 4.

The concentrations of pollutants suggested should not be slavishly copied. Urge the students to determine the levels which are actually entering the water in their area and to test these concentrations. This might help to emphasize that the solution to pollution must begin at home.

Seasonal Considerations:

Problems 1 and 3 would probably be best suited to seasons other than winter. Problems 2 and 4 could be conducted during any season. A winter field research could be conducted to determine the answer to problem 2, and problem 4 could be conducted with snails cultured in aquaria for this purpose.

PROJECTS USING FISH

Everyone is, of course, familiar with fish. However, not everyone is familiar with small fish. These generally are dismissed as "minnows", a term which really applies only to one group of small fish. If encouraged the student should soon be able to distinguish different small fish and will then be well on his way to recognizing the anatomical and behavioral adaptations each has evolved to allow it to survive in its particular niche.

Culturing native fish often presents problems. The two most common causes of these problems are overcrowding and excessively high water temperatures. Territorial fish such as sticklebacks, are particularly sensitive to overcrowding. Each male requires his territory and if more than two or three males are placed in an aquarium sized container, some will not be able to gain a territory. Parasitic infections are also more common in an overcrowded aquarium. The sudden appearance of fat bellies should alert you to this problem.

PROBLEM 1.

Students should be encouraged to relate the morphology of an animal to its habitat. If this aspect is stressed in this problem then the capturing of even one native fish could be a successful project. Students could be encouraged to consult Paetz and Nelson (1970) for some answers to the questions raised.

PROBLEM 2.

Fish are often used as a pollution test animal. Since different species of fish react differently to the same amount of pollutant, the most sensitive native species is often used. In many laboratories this means the use of rainbow trout. The use of "guppies" or goldfish or native fish could teach the same lessons in these projects. Since fish are expensive and difficult to obtain it might be suggested to students that they test only the initial reaction of a fish to a pollutant and that they remove the fish from the pollutant long before death would occur.

Seasonal Considerations:

The projects could be conducted during any season.

PROJECTS USING FROGS AND TOADS

The collection of frog eggs is a very popular pasttime for small boys. Often however, they experience difficulty in getting the eggs to change into tadpoles. The difficulty usually results from letting the water get too warm or from using tap water. The rate of development of a frog egg is dependent almost entirely on water temperature. A temperature of 50 to 60 degrees Fahrenheit most closely approximates field conditions, while temperatures over 75 degrees will generally prevent hatching.

PROBLEM 1.

The standard method of marking amphibians is by toe clipping. The first joint of the toes is removed with sharp scissors. Many number combinations are possible. For example, clipping the first toe on the right front foot and the second toe on the left front foot could designate frog number twelve. Encourage students to discover other methods of identifying the individual frogs or toads as well.

PROBLEM 2.

This problem contains many different activities. Students should be encouraged to select one factor, e.g. temperature, for intensive study rather than many factors for cursory studies.

c) pH - The pH should be adjusted with the use of a buffer like Na_2HPO_4. The water will quickly change to its original pH if adjusted using only an acid or base like HCl or NaOH. A chemistry text should have some tables providing the correct ratio of acid or base with buffer for each desired pH.

h) Predators - Suggest introducing dragonfly nymphs into the container.

PROBLEM 4.

Male frogs and toads are often vocal during the breeding season. The calls vary with the species. The first individual to call indicates the direction of the breeding sites to the rest of the population in the area. The call also advertises the presence of the male to females of the same species. Only the males give the breeding call. The sound of the call can be used to identify the species breeding while the volume can be used to determine the relative abundance of each species. Characteristic calls of some common frogs and toads in Alberta are given below. The Amphibian Checklist (Department of Zoology, University of Alberta), the Resource Reader (Saskatchewan Department of Natural Resources), and Stebbins (1954) supplied the information presented.

Boreal Chorus Frog (Pseudacris triseriata)

A rasping sound something like running a thumbnail over the teeth of a pocket comb.

Wood Frog (Rana sylvatica)

A low sharp "quack" often repeated several times in quick succession.

Leopard Frog (Rana pipiens)

A low drawn-out snore often followed by several rapid low grunts. A chorus of males produces a groaning, pulsating effect.

Canadian or Dakota Toad (Bufo hemiophrys)

A low trill.

Boreal Toad (Bufo boreas)

A birdlike chirping sound consisting of low, mellow, tremulous notes.

Seasonal Considerations:

Problems 1, 2, 3, and 4 are all problems best conducted in spring. Problem 5 could be conducted anytime adult frogs were available.

PROJECTS USING HOUSE SPARROWS AND STARLINGS

To eliminate any chance of students harming a native bird you should insure that they are able to recognize house sparrows and starlings. Salt and Wilk (1966) provide identification information for the house sparrow.

> "The black throat and bib and chestnut markings of the male are distinctive. The female is a dull gray sparrow lacking distinctive markings. The stocky build and raucous notes of the English sparrow help to identify it."

The starling may be confused with different blackbird species by students. Starlings are generally chunkier than blackbirds. In spring, their plumage is a glossy purple-green with numerous white flecks and the bill is yellow. During the winter the back feathers are much darker and edged in light brown and the bird is strikingly "speckled". The bill also turns to a bluish-black color. Males and females have the same colors. One of the most obvious features is the tail which is very short. They have short triangular wings and a very rapid wingbeat. They bob their beaks like a duck when they walk.

Seasonal Considerations:

The problem suggested in the students' section covers a wide range of research problems. Therefore it should be divided into smaller problems some of which could be conducted during any season of the year.

PROJECTS USING BREEDING BIRDS

Most breeding birds have territories of some type. Generally the males defend the territory using some type of challenge. The challenge may take various forms, the most common being singing and/or visual display. The red-winged blackbird is an excellent bird to study in this project. In spring one can generally see at least one of these males in every cattail marsh. Most often they are perched on the highest perch, for example a fence post, cattail or telephone pole, singing and displaying their red shoulder patches. The following excerpts from a report completed by Miss Sandra Lewin for a Biology 10 class in Edmonton, Alberta provide an excellent model for this type of project. Miss Lewin was kind enough to allow the use of the material.

"Breeding Ecology of a Population of Red-Winged Blackbirds
(Agelaius phoeniceus) at Edmonton, Alberta

INTRODUCTION

My father and I went out to a tributary stream of Big Lake, northwest of Edmonton, near St. Albert. This is a cattail marsh area with an adjacent wet meadow. We visited this area weekly during May and June, 1971 to study the breeding ecology especially in relation to sex ratio, territoriality, and nesting habits of Red-Winged Blackbirds (Agelaius phoeniceus) of a central Alberta population of this species which are near the northern edge of their range. A comparison was also made to two other studies conducted in a more southerly region.

METHODS

I surveyed the study area by canoe (See figure 1-3) on May 5, May 22, June 12 and drew a map plotting the position of territorial males as they appeared on May 5 (See map) and their females. Nests were found by observing females carrying building materials; by watching them carry food to young or by watching them flush from the nesting area. The nests were marked with florescent orange surveying tape which was numbered with a black waterproof felt pen. (See figure 5 and 7). The plastic tape was then tied on the cattails near the nest, so it could be easily located on the next visit. More information was collected by observing the number of eggs; and their appearance; what the nest was constructed of; the position in the vegetation; height from water; and distance from the open water. Photographs were also taken, of the general study area, the territorial males on singing posts, and the birds with their nests and young.

RESULTS

The study area was about 300 ft. by 200 ft. and 13 males were found in it. There were 19 females associated with these males. The largest territory was about 100 ft. by 100 ft. (10,000 ft.^{2}) and the smallest was about 50 ft. by 50 ft. (2,500 ft.^{2}). Each male had about 1.4 females in his territory. In other words I observed 32 Red-Winged Blackbirds in this total area. See map for distribution of territorial males and their females. The general territorial boundaries can be seen by observing the males on high posts or cattail stalks where they display by singing and flairing their brilliant red shoulder feathers (See figure 4).

Four nests were found. See map for location and see table 1 for further information on the nests."

Seasonal Considerations:

This project is restricted to spring.

PROJECTS USING WATERFOWL

Most students should be somewhat familiar with some waterfowl.

This knowledge can be used to initiate discussion regarding the interrelationship between birds and their habitat. For example, feeding habits, nesting areas and areas used for shelter may be discussed. The scope of the questions may be limited by stressing the variety of waterfowl, or the food eaten by different waterfowl such as mallards, pintails, Canada geese, etc. The following quotation taken from a Canadian Wildlife Service pamphlet entitled "Waterfowl - a Resource in Danger?" by Darrel Eagles, should provide a good basis for the projects suggested.

> "Once this continent had myriads of ponds, potholes and marshes. Blue water sparkled in the sunlight and every shade of green waved above the wetlands. Wild animals came to drink at the shores. The waters were rich with food, and great flocks of ducks and geese came to nest their downy young. The Indian hunted with bow and arrow, but he took little.
>
> Then the white man came. He marveled at the great honking V's of geese, and the flocks of ducks that at times formed vibrant everchanging clouds in the sky. But the white man hunted too, first with muzzle-loaders and black powder, then with repeating shotguns and long-range shells; first for food, for market for a time, then for sport.
>
> The birds were gunned on their autumn flight; they were gunned all during the cold months on the wintering grounds in the South, and again in spring and summer when they flew North to nest. The birds were given no respite, no sanctuary.
>
> And the once great flocks of waterfowl became smaller.
>
> The forests were cut, and gaping ditches were gouged in the black soil to drain the wetlands for market gardens and feed crops in the East and grain fields in the West. Sometimes the lands weren't suitable for crops and it was left parched and cracked, useless for anything, supporting no life.
>
> As they always had, droughts came and went, but with fewer natural reservoirs much of the land turned to dust and the dry winds swirled the soil up into choking clouds that darkened the sky.
>
> And the once great flocks of waterfowl became smaller.

> Sanctuaries were set up, and laws passed to restrict hunting seasons, hours, and bag limits. Sneak boats, baiting, live decoys, and market hunting were prohibited. But then as the droughts ended, the flocks became larger, and people forgot about the dust storms and started to drain their wetlands again. Sometimes governments helped with the drainage. Sometimes too they had to subsidize farmers when no markets could be found for extra crops.
>
> And the once great flocks of waterfowl became smaller.
>
> A great cry went up from hunters and naturalists, and from people who travelled to see the birds; a cry went up from the farmers, sporting goods manufacturers, photographers, and bird watchers. Many cried 'Stop all waterfowl hunting!' A few saw the real danger and advised 'Save the wetlands and you'll have waterfowl to enjoy.'"

Seasonal Considerations:

Spring and fall are the two best seasons for the projects suggested.

PROJECTS USING PHEASANTS AND GROUSE

In these problems early morning hours means shortly after sunrise. This is a good project for the entire class. For example, 30 students could work in pairs and select 15 different listening stations. All listening should be done on the same morning. A display model indicating the habitat and the number of pheasants or grouse could be exhibited for the benefit of other students in the school.

The following information by William Wishart, Wildlife Research Biologist, Alberta Fish and Wildlife Division (pers. comm.) may help determine the validity of the students' results.

> "In high pheasant years, a typical crowing index in the irrigation country of southern Alberta averages around 20 and in the parklands of central Alberta a typical index is around

> seven. In low years, the crowing index drops to four or five in the south and one or two in the parklands. In Alberta, there is a high correlation between pheasants or crowing indexes and winters preceeding the counts; i.e., severe winters are followed by a reduced index and mild winters are followed by an increased index."

Seasonal Considerations:

This is a spring project.

PROJECTS USING BEAVERS

A beaver study is always interesting. Most students are somewhat aware of their engineering skills and industry and their intimate association with our early history. This interest can be used to start students thinking about the interrelationships between the beaver and its habitat. Students may be asked to determine why beavers build dams, why they cut down trees, what they eat, and where they sleep. Students may wish to compare the effects of a beaver dam with that of a man-made dam. Both slow down the water, thereby causing silt to build up behind the dam. How does this change the characteristics of a stream behind a beaver dam as compared with the change behind a man-made dam? Man's action generally lowers and raises the water level behind the dam while the beaver's action does not. How does this affect the animals living in the water close to shore (littoral zone) and therefore, how does this affect the fish living in the stream? Why can one support stream-loving fish (e.g. trout) while the other has difficulty supporting lake type of fish?

Seasonal Considerations:

The project could be conducted during any season. The 1969 Alberta Department of Education Curriculum Guide for Biology 10, 20, and 30 has an outline of a project which could be conducted during any season. Students should however be cautioned not to contravene Section 59 of The Wildlife Act, Province of Alberta.

> "59. (1) No person shall cut, spear, open, break, partially destroy, or destroy
>
> (a) a beaver house or beaver dam
>
> (b) a muskrat runway or muskrat den except
>
> (i) the holder of a licence or permit under Section 61, or
>
> (ii) the holder of a certificate under Section 64.
>
> (2) No person shall set or place a trap in a beaver house or burrow or within five feet of a beaver house."

PROJECTS USING SMALL MAMMALS
(DEERMICE, VOLES, ETC.)

Generally the most common and most widely dispersed of the small mammals in North America are those belonging to the genus Peromyscus. These are variously known as the deermice, white footed mice, vesper mice, and wood mice. The deermice are inquisitive little animals rarely weighing more than an ounce. In some respects they resemble white tailed deer, having pure white under-surface, large, rounded ears and large black eyes. They are active at all seasons, but, of course, are more active in summer than in winter. Soper (1964) describes them as ". . . highly sensitive, timorous, alert and over-curious". They are very clean little animals and quite easily tamed. They, therefore, make excellent animals to be kept in a classroom. They are, however, nocturnal, spending most of the day curled up asleep.

The other groups of common small rodents which can be collected by the students are the meadow voles, genus *Microtus*, and the red-backed voles, genus *Clethrionomys*. Students probably have encountered both of these groups though they probably called them mice. Studying the different preferred habitats and the adaptations to these habitats (problem one) should enlarge their view of these rodents. The runways of the meadow voles are especially interesting and are relatively easy to locate. If one parts the grass in a matted mixed grass area such as that found in a meadow or beside woods or roadsides, one can generally see a network of well-trodden trails. These little highways, about one inch wide, generally contain grass cuttings and some scattered droppings. The advantages of such a network to the vole could be discussed. Some protection from predators (owls, hawks, coyotes, etc.), a place to store food, and an air space under the snow in winter, are just three. The effects of snowmobiles on this habitat and therefore, on the vole and the food chain depending upon the vole may also be discussed.

PROBLEM 1.

The absolute number of animals caught will vary of course, not only with the habitat but also with factors such as the season, year, stage of cycle, etc. Soper, 1964 when discussing the Boreal White-Footed Mouse states:

> "One must not leave the impression that the white-footed mice are always abundant, or common. On the contrary, at various times and places they become very scarce. This suggests real cyclic changes in the population, but a regular, periodic rhythm, if it exists, has not yet been satisfactorily clarified in Alberta. Moreover, great reductions in numbers can prevail in one part of a region when, simultaneously, abundance holds away in another."

PROBLEM 2.

Problem 2 in the students' section would be most successful if animals were first located. Therefore it would appear logical to have students conduct this project after problem 1 in the students' section had been conducted.

PROBLEM 4.

All are most active at night.

PROBLEM 5.

The Alberta Department of Education Curriculum Guide for 1969 for Biology 10, 20, and 30 has outlined some winter projects.

Seasonal Considerations:

With the exception of problem 5 most of the projects as outlined would be most successful in spring, summer and fall. Some parts of the projects could be conducted in the winter, especially if mice are captured in the fall and maintained in the laboratory.

PROJECTS USING POCKET GOPHERS

Collecting:

Few people ever see this animal. This is because the pocket gopher prefers to spend part of the night digging tunnels and eating roots and part of the day sleeping. It even solidly plugs each burrow opening from the inside to prevent light from disturbing it during these times. A study of its predators should indicate that it does spend some time above the surface of the ground.

> "Despite the brief and irregular appearances at the burrow mouth during the day, many of the creatures succumb to the attacks of hawks and carnivores mammals. Likewise, during the night when travelling or foodforaging above ground, owls and other nocturnal predators succeed in taking many individuals" (Soper, 1964).

PROBLEM 1.

Pocket gophers are fiercely territorial and except during breeding season will defend their network of tunnels against any other pocket gopher, both male and female. A single female is tolerated for a brief period in spring. The number of dirt mounds one sees in an area is therefore, really not indicative of a large number of gophers. Each animal may push up 30 to 50 mounds a year. The long, rope-like dirt accumulations provide evidence of their winter works program. As mentioned in the students' section this animal is often wrongly called a mole in Alberta.

PROBLEM 2.

Soper (1964) provides an excellent morphological description. For example: "The nearly naked tails of pocket gophers apparently possess specialized sensitivity; this refinement enables them to deftly feel their way in the tunnels when it is desirable to run rapidly in reverse".

PROBLEM 3.

> "The species is persistently prolific, normally having from four to eight young at a time; they are usually born in June and July. There is also evidence that more than one litter may be born to a mother in the same season, especially in races to the south" (Soper, 1964).

As noted in the students' section different live traps could be used. For example the Gen Trap (see ground squirrel project) or a similar type of trap could be tried. Steiner[1] (pers. comm.) suggested that his modified version of the Prychodko ground squirrel trap could be used for pocket gophers (Figure 8a).

Seasonal Considerations:

As mentioned they are active during all seasons. However, they would be difficult to study during winter. Therefore, spring, summer, and fall would be the most suitable study periods. Reproductive season should produce more gophers per trap.

PROJECTS USING TREE SQUIRRELS

The most common tree squirrel is, of course, the red squirrel. This curious, active, saucy and noisy animal is active by day and even on moonlit nights. They do not hibernate and so could be studied all year. Red squirrels have definite territories, the size of which appears to vary in winter and summer. The average winter size appears to be about one acre. The following excerpts from a paper written by Kemp and Keith (1970) might be of some interest.

---

[1] Dr. A. L. Steiner, Department of Zoology, University of Alberta.

> "This paper describes red squirrel population dynamics on two intensive study areas (Camp and Main) in mixed-forest types near Rochester, Alberta.
>
> Red squirrel territories appeared to be of two distinct types: (1) defended winter food caches which were subsequently abandoned during the summer, and (2) 'prime' territories in which a specific area was defended year round.
>
> Red squirrels were captured in unbaited National Livetraps, size 15 by 15 by 48 cm, placed on runways; trap density was roughly proportional to numbers of active runways. This technique resulted in 264 captures during 1967 and 1968. A numbered toe-clipping system (Melchior and Iwen, 1965) provided permanent identification of livetrapped squirrels, while colored ear wires (Halvorsen pers. comm.) allowed individual field recognition. Of the 12 animals marked during the summer on the Camp study area and recovered in the summer of 1968, 8 had retained both ear wires in good condition, 3 had lost 1 wire and 1 animal had lost both. Differential application of Nyanzol D dye (Melchior and Iwen, 1965) permitted visual separation of juveniles and adults during the summer months.
>
> Territory ownership was determined from defensive vocalization (Smith, 1968), from chases of squirrels released after livetrapping, and from recurring localized observations of the marked occupant."

PROBLEMS 1 and 2.

These problems should help the student discover the interrelationship between habitat and squirrels and the spacing of the squirrels in the preferred habitat. A discussion regarding the mechanisms used by squirrels to insure an adequate food supply for future generations may be appropriate. Contrasting their method with man's may be an interesting exercise. Some of the ways the squirrels manage this are by maintaining territories, thereby limiting the number of squirrels in an area, and spreading seeds and pruning trees as a result of their eating habits, thereby insuring a future food supply.

PROBLEM 3.

The projects could be literature research problems followed by field observations and experiments.

Seasonal Considerations:

The projects could be conducted during any season.

PROJECTS USING GROUND SQUIRRELS

"In the English vernacular, this jocular rodent got away to an unfortunate start, inasmuch as nearly everyone calls it a 'gopher'. This blunder having been committed and unrectified, the genuine pocket gopher was saddled with the name 'mole'-ironically enough in a land where no real moles exist! Chances for universal correction of this error now appear to be very remote indeed" (Soper, 1964).

PROBLEM 1.

The relationship between habitat and animal distribution should be very clear to the student upon completion of this project. Population counts should demonstrate that the edge between two ecosystems provides a greater diversity of habitats than either one by itself and should therefore, provide the greatest number of different species of animals. Having students look at the stomach contents might also help them to see that certain animals may live in one area but may eat in another.

If at all possible students should select two adjacent habitats, both of which can be observed simultaneously from one viewing location.

PROBLEM 2.

This problem can be used very successfully to teach the importance of keeping the mind open for further evidence. The student will probably find one factor which he might decide to be _the_ limiting factor in that area. He may be right for his period of observation. However, at other times of the year, other factors may be more important. Any one suggested measurement may, of course, be a project in itself.

Seasonal Considerations:

Ground squirrels generally hibernate for successive periods from about September to April. Therefore, spring (May, June) is the best time for these projects. Some winter projects could be conducted if the squirrels are captured alive and maintained in the classroom. A cage such as the one suggested in the Students' Section (Appendix A-18) could be used. One suggested project could be to induce hibernation. Kluchky[1] (personal communication) recommended the following procedures and tests.

1. Place the animal in a screened top wooden or plastic container. This container should contain some bedding material such as Terylene fiber but doesn't have to contain any food or water. Terylene fiber

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[1] Mr. K. Kluchky. Science Consultant. Department of Education, Government of Alberta, Edmonton.

is used for making quilts and comforters and so should be available in most department stores. The animal should now be placed in a temperature of 40-45 degrees F. i.e. in a refrigerator. If the animal is in the correct physiological state for hibernation (e.g. fat enough) then it should go into a torpor within two or three days. If the animal doesn't go into torpor then it should be removed and the experiment should be tried at a later date.

The animals can be aroused from hibernation by removing them from the cold environment and allowing them to warm up at room temperature. The arousal time is generally about one to two hours. The following tests could be conducted in conjunction with this project.

a) Detecting weight changes:

The weight of the animals could be recorded prior to hibernation and then every two days during hibernation. These data gathered over a short time period could be extrapolated to provide the calculated weight loss of the ground squirrel during the normal hibernation period. The accuracy of this extrapolation could be checked by capturing and weighing a representative sample (e.g. 10) ground squirrels in the fall and again in the spring. The project could be extended to capturing and weighing a representative sample of ground squirrels after the mating season to determine which of these "activities", hibernation or mating, caused the greatest weight loss.

b) Temperature changes:

Cheek pouch and shallow rectal temperatures could be recorded prior to hibernation, during hibernation and during the arousal period. The student should detect definite anterior-posterior temperature differences during the arousal period.

c) Behavior changes:

For example; the position of the animal when hibernating, time length of arousal, change of rate of respiratory movements during arousal, shivering, chattering of teeth, opening of the eyes, fluffing of the tail, etc. A discussion regarding the adaptive value of hibernation and the significance of the position during hibernation, i.e. minimize heat (energy) loss, could be very interesting at this time.

SNOW PROJECTS USING RABBITS, HARES, DEER, WAPITI (ELK), MOOSE

A brief description of the feeding habits of some of the mammals mentioned might be helpful. Since food habits vary with species, the following can only be considered as general information.

Rabbits and Hares:

Summer: Food consisting of a wide range of vegetable matter. Grasses, clovers, buds and leaves are some of the most common.

Winter: The animals are generally forced to eat dried grass, twigs, buds and bark.

Deer:

Summer and Winter: Their main diet is brushwood, twigs, and leaves of trees. Note that deer are browsers not grazers.

Wapiti (elk):

Summer: Mainly feeds on grass.

Winter: They mainly browse on deciduous trees and shrubs. They will also feed on the bark of both deciduous and coniferous trees.

Moose:

Summer: Enjoys water plants, twigs and foliage.

Winter: Browses on deciduous shrubs and trees.

PROBLEMS 1 and 2.

Students will probably have the most success in examining the vegetation near tracks after a fresh snow. Direct observation, inspection of pellets and analysis of stomach contents are all quite difficult techniques. Some of the answers might have to be obtained in the literature or could be obtained through discussions with Fish and Wildlife biologists and officers, local naturalists, and hunters.

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APPENDIX A

PRINCIPLES AND CONCEPTS OF ECOLOGY CROSS-INDEXED WITH THE PROBLEMS

The problems indicated should illustrate the following principles and concepts of ecology.

1. Principles and concepts pertaining to energy in ecological systems.

   Example: Productivity, food chains, food webs, trophic levels, ecological pyramids.

   Protozoans - 3; Hydras - 2; Leeches - 3, 5; Crustaceans - 1; Grasshoppers - 1; Cockroaches - 1; Aquatic Bugs - 1; Terrestrial Beetles - 1; Caterpillars - 1; Ants - 1; Spiders - 3; Sparrows - 1; Waterfowl - 1; Beavers - 1; Squirrels - 1; Ground Squirrels - 2; Rabbits - 1.

2. Principles and concepts pertaining to biogeochemical cycles.

   Example: Sedimentary cycle, cycling of organic nutrients, recycle pathways.

   Earthworms - 2; Aquatic Worms - 1, 2; Grasshoppers - 1; Cockroaches - 1, 2; Terrestrial Beetles - 1; Caterpillars - 1; Ants - 1, 3; Snails - 1; Waterfowl - 1.

3. Principles pertaining to limiting factors.

   Example: Liebig's "Law of the Minimum," Shelford's "Law of Tolerance," physical and biological conditions of existence as regulatory factors.

   Protozoans - 1, 2, 3; Hydras - 1; Planarians - 1, 2; Earthworms - 2, 3; Aquatic Worms - 1; Leeches - 1; Crustaceans - 1, 2; Grasshoppers - 1, 2, 3; Cockroaches - 1, 2; Aquatic Bugs - 3;

Caterpillars - 2; Houseflies - 2; Mosquitoes - 2; Mites - 1; Spiders - 1, 2; Snails - 1; Frogs 1, 2, 5; Sparrows - 1; Breeding Birds - 1; Waterfowl - 1; Pheasants - 1, 2; Beavers - 1; Mice - 1; Tree Squirrels - 1; Ground Squirrels - 1, 2; Rabbits - 1.

4. Principles and concepts pertaining to organization at the community level.

Example: Ecological dominance, species diversity, edge effect, patterns in communities.

Protozoa - 1; Planarians - 1; Earthworms - 1; Leeches - 1; Aquatic Worms - 1; Crustaceans - 1; Grasshoppers - 1; Mosquitoes - 1; Spiders - 1; Fish - 1; Sparrows - 1; Breeding Birds - 1; Waterfowl - 1; Mice - 1; Tree Squirrels - 1; Ground Squirrels - 1; Rabbits - 1, 2.

5. Principles and concepts pertaining to organization at the population level.

Example: (a) Relative abundance, rates of natality, mortality, population age distribution, carrying capacity, population oscillations, density - independent and density - dependent factors.

Protozoa - 4, 5, 6; Planarians - 1; Aquatic Worms - 1; Leeches - 1, 4; Crustaceans - 1, 2; Grasshoppers - 1, 2, 3; Cockroaches - 1; Aquatic Bugs - 3; Houseflies - 1; Spiders - 1, 4; Fish - 1; Frogs - 1, 2, 4, 5; Sparrows - 1; Breeding Birds - 1; Waterfowl - 1; Mice - 2; Pocket Gophers - 1; Tree Squirrels - 1; Ground Squirrels - 2; Rabbits - 2.

(b) Population structure such as dispersion, (random, uniform, clumped), aggregation, isolation and territoriality.

Protozoa - 6; Earthworms - 3; Aquatic Worms - 1; Leeches - 1; Crustaceans - 1; Grasshoppers - 1; Caterpillars - 2; Ants - 2; Spiders - 1; Fish - 1; Frogs - 4; Sparrows - 1; Breeding Birds - 1; Waterfowl - 1; Mice - 1,2; Pocket gophers - 1; Tree Squirrels - 1,2; Ground Squirrels - 2.

(c) Population interactions: Predation, parasitism, commensalism, cooperation, mutualism.

Protozoa - 3, 6; Hydras - 2; Leeches - 5; Crustaceans - 2; Aquatic Bugs - 1; Mosquitoes - 3; Ants - 1; Mites - 3; Spiders - 3; Snails - 3; Fish - 1; Frogs - 2, 5; Sparrows - 1; Waterfowl - 1; Ground Squirrels - 2.

6. Principles and concepts pertaining to the species and individual in the ecosystem.

Example: Habitat, ecological niche, regulatory and compensatory behavior.

Protozoa - 1, 2; Hydras - 1, 2; Planarians - 1; Earthworms - 1; Aquatic Worms - 1, 2; Leeches - 1, 2; Crustaceans - 1, 2; Grasshoppers - 1, 3; Cockroaches - 1; Aquatic Bugs - 2, 3; Caddis Flies - 1; Mosquitoes - 1, 4; Ants - 1; Mites 1, 2; Spider - 1, 2; Snails - 1, 2; Fish - 1, 2; Frogs 1, 2, 3, 4, 5; Sparrows - 1; Breeding Birds - 1; Waterfowl - 1; Pheasants - 1, 2; Beavers - 1; Mice 1, 4; Pocket gophers - 1, 2; Tree Squirrels - 1; Ground Squirrels - 1; Rabbits - 2.

7. Principles and concepts pertaining to development and evolution of the ecosystem.

Example: Succession, climax.

Protozoa - 4, 5; Aquatic Worms - 2; Crustaceans - 1; Grasshoppers - 1; Beetles - 1; Spiders - 1; Breeding Birds - 1; Beavers - 1; Mice - 1; Tree Squirrels - 1.

8. Pollution Problems, Per Se.

Hydras - 3; Earthworms - 4; Aquatic Worms - 2; Leeches - 6; Mosquitoes - 5; Mites - 3; Snails - 4; Fish - 2; Frogs - 2.

APPENDIX B

SELECTED REFERENCES FOR ALBERTA TEACHERS

Prices are approximate

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